Investigating the use of social media to improve calcium intake of young adults

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Abstract

Calcium intake is low in the Australian population, particularly in adolescents as they transition into adulthood. Dairy is considered to be the best source of calcium which is an essential nutrient for reaching peak bone mass. Calcium has also been associated with reducing the risk of osteoporosis, metabolic syndrome and other chronic diseases. However, it is thought that young adults are typically not concerned about health problems that are distal in nature. Electronic technology has become increasingly popular and has gained the attention of a younger audience through elements of communication, such as social media. The overall aim of this project was to investigate the use of a social media intervention via Facebook to improve calcium intake of young adults.

Chapter One contextualises this thesis within the current evidence bases, defines key thesis concepts and aims, and provides an outline of the thesis. Chapter Two presents a narrative review on calcium intake and its health implications for the population, with a particular focus on young adults. This review found that the current evidence base suggests that calcium is an important nutrient for this age group and interventions should be implemented to improve sub-optimal intakes. Chapter Three presents a secondary analysis of the most recent National Nutrition and Physical Activity Survey (2011-12) to examine calcium intakes and food groups consumption and dietary patterns in Australian adolescents and young adults. The research indicated that calcium intake remains low in Australian adolescents and young adults, particularly in females; and a higher intake of calcium was associated with better diet quality.

Chapter Four presents a systematic literature review of existing interventions that aimed to improve calcium or dairy intake of young adults. This review found some evidence demonstrating that calcium and dairy interventions are effective but the effect size is small. The body of evidence is limited by the both the number and size of the interventions. It was

unclear from the information reported how the interventions were developed which makes it difficult to decipher the 'active elements'. Few studies incorporated behaviour change theories or techniques. Thus, it was recommended that future studies include behaviour change techniques such as goal-setting, self-monitoring and the use of social media to provide social support.

Chapter Five presents results from focus groups which were conducted with young adults to understand the psychosocial determinants and possible barriers to achieving adequate calcium intake. Key themes were identified from participant responses which included general calcium knowledge, enablers and barriers to intake, and the potential role of social media in an intervention. The themes were then grouped using the COM-B framework into those relating to Capability, Opportunity and Motivation.

Chapter Six describes the development of a cross-sectional web-based survey that was conducted to determine what type of messaging is preferred by young adults to improve their calcium intake. The findings of this research were analysed qualitatively using direct quotes from participants and quantitatively which involved ranking of text messages and mock Facebook posts.

Chapter Seven describes the theoretical framework and development process for a social media intervention program to increase calcium intake among young adults. This was performed using the COM-B model and Behaviour Change Wheel (BCW). Chapter Eight presents the primary and secondary outcomes of the RCT after the six-week intervention period. At six weeks, the participants in the Facebook and text message group had improved knowledge but not intake of calcium. This thesis concludes with Chapter Nine which discusses the overall findings within the context of existing research in this field and describes future implications of this research for the population at large.

Declaration

This is to that to the best of my knowledge; the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Anika Rouf
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Ethical approval

Methods and materials of the six-week intervention (CAN-DO study) presented in Chapter 7 were approved by the Human Ethics Research Committee at The University of Sydney in July 2018 (Approval Number 2018/597).

Methods and materials of the formative research detailed in Chapter 5-7 were approved by the Human Ethics Research Committee at The University of Sydney in March 2017 (Approval Number 2017/218), October 2017 (Approval Number 2017/718) and February 2018 (Approval Number 2018/079).

Note on authorship attribution

I Anika Saiyara Rouf (the candidate) hereby declare that no part of this thesis has been submitted for a degree at the University of Sydney or at any other tertiary institution. The research presented in this thesis was conducted by the candidate under the guidance of my primary supervisor Professor Margaret Allman-Farinelli. Additionally, contributions were made by the following co-authors; Associate Professor Anna Rangan, Dr Zhixian Sui, Dr Monica Marina Nour, Ms Amanda Grech, Ms Steffani Clayton and Ms Vienna Bramston. All work presented in this thesis is the original work of the candidate and the aforementioned supervisors and co-authors.

I, Anika Saiyara Rouf (the candidate), under the guidance of my primary supervisor Professor Margaret Allman-Farinelli developed the research question and rationale presented in Chapter One and Two. In Chapter Three, I analysed the data under the guidance of Dr Zhixian Sui. I also devised the protocol and conducted the systematic literature review and meta-analysis described in Chapter Four. Chapter Five was conducted with the help of a research student who is also an equal co-author. I conducted the focus groups and took part in writing the first draft of the paper. I was the primary researcher involved in developing the research question and producing the final manuscript presented in Chapter Six. For Chapter Seven and Eight, I conducted the intervention, analysed the data and wrote the first version of the manuscript. I wrote the final chapter and sought feedback from my supervisor.

Authorship attribution statement

In addition to the statements above, in cases where I am not the corresponding author of a published item, permission to include the published material has granted by the corresponding author.

Anika Rouf
29th November 2019

As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statements above are correct.

Margaret Allman-Farinelli
29th November 2019

Publications

The following peer-reviewed publications arose directly from research conducted as part of the PhD candidature:

Manuscripts published or accepted for publication (first author)

1. **Rouf A**, Grech A, Allman-Farinelli M. Assessing the efficacy and external validity of interventions promoting calcium or dairy intake in young adults: a systematic review with meta-analysis. Critical Reviews in Food Science and Nutrition. 2017.

2. **Rouf A**, Sui Z, Rangan A, Grech A, Allman-Farinelli M. Low calcium intakes among Australian adolescents and young adults are associated with higher consumption of discretionary foods and beverages. Nutrition. 2018;55-56:146-53.

3. **Rouf A**, Allman-Farinelli M. Messaging for Interventions Aiming to Improve Calcium Intake in Young Adults-A Mixed Methods Study. Nutrients. 2018;10(11).

4. **Rouf A**, Clayton S, Allman-Farinelli M. The barriers and enablers to achieving adequate calcium intake in young adults: a qualitative study using focus groups. J Hum Nutr Diet. 2019.

5. **Rouf A**, Nour M, Allman-Farinelli M. Improving Calcium Knowledge and Intake in Young Adults Via Social Media and Text Messages: Randomized Controlled Trial: a three-arm six-week randomised controlled trial with process evaluation JMIR mHealth and uHealth. 2020;8(2):e16499

Additional peer-reviewed publications completed during the PhD candidature:

6. Nour MM, **Rouf A**, Allman-Farinelli M. Exploring young adult perspectives on the use of gamification and social media in a smartphone platform for improving vegetable intake. Appetite. 2018;120(Supplement C):547-56.

7. Hsu MSH, **Rouf A**, Allman-Farinelli M. Effectiveness and Behavioral Mechanisms of Social Media Interventions for Positive Nutrition Behaviors in Adolescents: A Systematic Review. The Journal of adolescent health: official publication of the Society for Adolescent Medicine. 2018;63(5):531-45.

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9. Bramston V, **Rouf A**, Allman-Farinelli M. The Development of Cooking Videos to Encourage Calcium Intake in Young Adults. Nutrients. 2020;12(5).

Conference presentations

The following abstracts arose directly from research conducted as part of the PhD candidature:

Oral presentations:

1. Rouf AR et al., intake and dietary sources of calcium among Australian adolescents and young adults: a secondary analysis of the Australian 2011-12 national nutrition and physical activity survey, *Dietitians Association of Australia 34th National Conference*, 2017, Hobart, Australia
2. Rouf AR et al., Efficacy of interventions promoting calcium or dairy intake in adolescents and young adults: a systematic review with meta-analysis, *International Society of Behavioural Nutrition and Physical Activity*, 2017, Victoria, Canada
3. Rouf et al., Using the COM-B framework to explore the barriers and enablers to calcium intake in young adults: a qualitative study using focus groups, *CBC Digital Health Conference 2018: Behaviour Change for Health: Digital and Beyond*, 2018, London, England
4. Rouf et al., Using the COM-B framework to explore the barriers and enablers to calcium intake in young adults: a qualitative study using focus groups, *Dietitians Association of Australia 35th National Conference*, 2018, Sydney, Australia

Poster presentations:

1. Rouf AR et al., Intake and dietary sources of calcium among Australian adolescents and young adults, *International Congress of Nutrition*, 2017, Buenos Aires, Argentina
2. Rouf AR et al., Exploring motivation to cook in Australian young adults using qualitative research, *International Society of Behavioural Nutrition and Physical Activity*, 2018, Hong Kong, China
3. Rouf AR et al., Applying the COM-B model and behaviour change wheel to develop a Facebook intervention to improve calcium intake among young adults, *International Society of Behavioural Nutrition and Physical Activity*, 2018, Hong Kong, China

Symposium presentations:

1. Rouf AR et al., Using focus groups to develop a social media intervention to improve calcium intake among young adults, *Early Mid-Career Researchers Committee Symposium*, Charles Perkins Centre, 2017, Sydney, Australia (poster presentation)
2. Rouf AR et al., Testing the preferred tone of messages for an intervention aimed to improve calcium intake in young adults, *Early Mid-Career Researchers Committee Symposium*, Charles Perkins Centre, 2018, Sydney, Australia (oral presentation)

Additional conference presentations arising during PhD candidature

1. Nour M, **Rouf A** and Allman-Farinelli M; Testing of a smart-phone platform using social media and gamification to improve vegetable intake in young adults: Focus group findings. International Society of Behavioural Nutrition and Physical Activity, 2017, Victoria, Canada

2. Hsu M, **Rouf A** and Allman-Farinelli M; Effectiveness and behavioural mechanisms of social media-based interventions promoting positive nutrition behaviours in adolescents: a systematic review, *Dietitians Association of Australia 35th National Conference*, 2018, Sydney, Australia

Awards and prizes

2017: FameLab NSW semi-finalist

2016: Best Novice Researcher Poster Award- highly commended (*Dietitians Association of Australia*)

2016 Australian Postgraduate Award Recipient from the Commonwealth Government of Australia

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List of Abbreviations

ABS	Australian Bureau of Statistics
ADA	American Dietetic Association
ANOVA	Analysis of variance
BCT	Behaviour Change Technique
BMD	Bone Mineral Density
CI	Confidence interval
CAN-DO	CAlcium Nutrition-Dietary Opportunities
COM-B	Capability Opportunity Motivation and Behaviour
EAR	Estimated Average Requirement
eHealth	Electronic health
FAO	Food and Agriculture Organization
FG	Focus group
GRADE	Grading of Recommendations Assessment, Development and Evaluation
GEE	General Estimating Equation
MeSH	Medline thesaurus Medical Subject Headings
mHealth	Mobile health
NNS	National Nutrition Survey
N/A	Not available
NNPAS	National Nutrition and Physical Activity Survey
NR	Not reported
OR	Odds Ratio
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
RCT	Randomized Controlled Trial
RDA	Recommended Dietary Allowance
REDCap	Research Electronic Data Capture
RNI	Recommended Nutrient Intake
SD	Standard deviation
SEIFA	Socio-Economic Indexes For Areas
UK	United Kingdom
US	United States
WHO	World Health Organisation

Chapter One

Introduction

"Intervention for the prevention and control of osteoporosis should comprise a combination of legislative action, educational measures, health service activities, media coverage, and individual counselling to initiate changes in behaviour."

- Gro Harlem Brundtland (Director-General of the World Health Organisation)

1.1 Introduction to the chapter

This thesis aims to study calcium intakes in Australian young adults as it is an important factor for the prevention of osteoporosis. Having established suboptimal intakes, the thesis describes the development and testing of a program that includes education and intervention to initiate changes in personal behaviour. Chapter one describes the target population (section 1.2 to 1.4) and provides key thesis concepts and aims (section 1.5) and an outline of the thesis describing how each chapter meets the thesis objectives (section 1.6).[1]

[1] Five chapters of this thesis have been published. Thus, layout, terminology and English language per chapter is in accordance with journal requirements and referencing in each chapter is maintained in the journal referencing style. Unpublished chapters (Chapter One, Chapter Two, Chapter Seven and Chapter Nine) use Australian English and Vancouver referencing style. Reference lists appear after each chapter to match the published work.

1.2 Background

Adequate calcium intakes during adolescence and young adulthood are important for attaining peak bone mass as approximately half of our peak bone mass is accumulated during adolescence and is reached by the mid-20's (1). Despite the established benefits of calcium consumption, many young Australians are not meeting the recommendations for calcium intake. The most recent National Nutrition Survey conducted in 2011-12 shows calcium intake to be inadequate in 44.2% males and 71.3% of females aged between 19 to 30 years (2). The prevalence of inadequacy was much higher amongst females than males, with nine out of 10 females having inadequate intake in their adolescence. Bone accretion continues during adolescence with peak bone mass reached in the third decade of life. Thus, calcium intakes during adolescence and young adulthood are particularly important to prevent osteoporosis in older age. The group to be studied in this thesis is young adults (18 to 25 years) rather than adolescents as they are the somewhat forgotten age group in health promotion (3). They are a difficult-to-reach population with relatively low healthcare utilisation which makes it difficult to disseminate information in this age group (4-6).

This thesis will explore calcium intakes of young adults in detail which includes food sources, supplements and intake patterns, as well as barriers and enablers to achieving adequate calcium intake. Milk and milk-based foods are the richest sources of calcium in the Australian diet (2) which is similar to other western countries (7-9). However, alternate sources are available for those who may be dairy, lactose intolerant or choose to avoid it for other reasons. Some non-dairy food sources include leafy green vegetables (e.g. spinach, kale) firm tofu, almonds, canned salmon and sardines. When fortified with calcium, soy milk has been thought to be the best alternative out of the other plant-based alternatives, followed by almond milk (10).

1.3 Young adults as a target for interventions

Young adults are a vulnerable population as this period is characterised by transition and change. Intake of meals prepared outside the home frequently increases and consumption of foods from the recommended food groups (i.e. fruits, vegetables and dairy) may decline. Previous research has shown that young adults have the worst diet amongst adults and have the quickest rate of weight gain out of all age groups (11, 12). There are unique idiosyncrasies of this life period which include being time poor, juggling work and study commitments, adjusting to increased independence, changing employment and living conditions and an increased requirement to self-manage their time whilst keeping up with potentially new social circles and norms (13-16). Price of food is often a consideration for this demographic (17). This means that time poor young adults are attracted to meals which are convenient and affordable. Moreover, it is thought that the relative ease of access and availability of unhealthy foods contributes to poorer quality diets as young adults perceive contemplation and execution of a healthy diet as a burden (17).

Some barriers to healthy eating may include limited income, lack of time, as well as poor food preparation and cooking skills (18). As a result, young adults nowadays have become a 'grab and go' society and are the highest consumers of convenience foods (19). This is concerning as these foods are usually energy dense and contain higher levels of sodium, saturated fat and refined sugar and lower amounts of important nutrients (20).

Qualitative research has found that being seen to eat healthily and eating foods that have been branded as 'healthy' is associated with being less popular, particularly in young people and those from lower socioeconomic backgrounds (21, 22). The reasons for this are unknown and further work is needed to understand the attitudes of consumers (20). A recent scoping review has revealed that there are multifaceted contributors to food choice which encompasses intrapersonal, interpersonal and wider cultural and socioeconomic factors (17).

Previous research has found that having an incentive is integral to changing dietary behaviour among young adults (17). The enablers to healthy eating for young adults included gender-based (female) interest in and implementation of a healthy diet; healthy diets of friends and family; support and encouragement of friends and family to eat healthy; desire for improved health; desire for weight management; desire for improved self-esteem; desire for attractiveness to potential partners and others; possessing autonomous motivation to eat healthy; existence and use of self-regulator skills and increased planning, automaticity and habit of healthy eating (17). In contrast, the key barriers for young adults included gender-based (male) apathy towards health and diet; unhealthy diet of friends and family; expected consumption of unhealthy foods in certain situations; relatively cheapness of unhealthy foods; lack of time to plan, shop, prepare and cook healthy foods; lack of facilities to prepare, cook and store healthy foods; widespread presence of unhealthy foods; lack of knowledge and skills to plan for; shop, prepare and cook healthy foods; lack of motivation to eat healthily; lack of self-regulation behaviours; preferred taste for unhealthy food; baseline hunger and lack of satiation and emotional responses (e.g. stress) that increased appetite and preference for unhealthy foods (17).

The personal relevance of messages can lead to an increase in motivation to perform a desirable behaviour. Research has shown that tailoring interventions and providing personally relevant feedback to participants may lead to improved outcomes (23, 24). Providing direct support to young adults may assist with building self-efficacy for incorporating healthy foods into their diet (25). In order to conduct effective nutrition interventions, it is important to consider the unique idiosyncrasies of young adulthood and the impact these may have on eating habits. Many young adults have irregular meal patterns (26) and perceive eating healthy as a significant challenge (27). However, this life stage may present a unique opportunity to positively influence their nutrition habits as they are malleable to change. Obviously because

of the importance of bone growth during childhood and adolescence most interventions to improve calcium intakes have been targeted to this life stage or the elderly who have osteopenia and osteoporosis. This thesis addresses young adults as a neglected group and suggests as young adults are likely to be procreators in the near future, influencing their eating habits may have positive implications for future generations. A recent meta-analysis has revealed a strong association between the food behaviours modelled by parents and the consumption patterns of their offspring (28).

1.4 Determinants of low calcium intake

In order to support young adults to change their diets, it is necessary to understand the determinants of eating behaviour. Australians continue to struggle with meeting calcium intakes and the recommended servings of dairy foods and alternatives. Milk intakes in particular are low. The health-related beliefs, socio-cultural norms and barriers to change of younger generations differ from the general adult population. Some barriers that have been identified previously in the adolescence population include personal knowledge about dairy products and misconceptions regarding dairy foods and their associated health benefits; food characteristics (including taste), personal behaviours such as habits or routines; social environments (including parental and peer influence); physical environment (such as availability); and the convenience of dairy products (29).

A systematic review conducted in European countries has shown that higher occupational level was associated with consumption of cheese and skim milk (30). A cross-sectional study conducted in Korea has reported low calcium intake in regions with lower socio-economic status (31). A New Zealand study has also suggested a link between dairy and social equity where milk consumption was directly related to socio-economic status (32). A cross-sectional survey from Switzerland with adults (35-74 years) has found that ‘low-education’ men

consumed more calcium than ‘high-education’ men while ‘low-occupation’ women consumed less calcium than ‘high-occupation’ women (33). While it is apparent that there may be disparities present based on socio-economic factors, it is not known if a disparity in calcium intake exists for young adults in Australia for factors such socioeconomic status (SES), income and geographic location. A systematic review on global calcium intake has reported no clear patterns across countries in relation to age, sex or socioeconomic status (34). Further research is warranted.

1.5 Thesis aims

From the available evidence, it is clear that calcium intake is sub-optimal in Australian young adults. In order, to improve the dietary patterns of young adults including their calcium intake a program specifically targeted to their unique needs is required. This thesis describes the development and trial of a nutrition promotion program (using social media and text messaging), with a particular focus on calcium intake.

The specific aims of this research are:

(1) To determine the calcium intake in the young Australian population by demographic factors, examine food sources and intake patterns to gain insight into intervention points (Chapter Three)
(2) To systematically investigate the effectiveness of previous interventions aimed at improving calcium or dairy intake in young adults, and the generalizability and applicability of these studies for current practice (Chapter Four)
(3) To conduct formative research with a sample of the target audience to explore the enablers and barriers to adequate calcium intake (Chapter Five); and gather feedback on the relevance and appropriateness of pilot intervention materials. This included

developing cooking videos (Appendix 7) and conducting a survey to gather preferences for messaging and acceptability of sample social media posts and text messages (Chapter Six)

(4) To develop a social media intervention using the findings of aims 1, 2 and 3 to improve calcium intake of young adults (Chapter Seven). The six-week CAlcium Nutrition-Dietary Opportunities (CAN-DO) was a randomised controlled trial using the Capability, Opportunity, Motivation and Behaviour framework of Michie et al (35)

(5) To test the CAN-DO program with young adults using a three-arm randomised controlled trial (Chapter Eight)

(6) To establish the key findings, their implications for this area of research and provide practical recommendations for future work in this area (Chapter Nine)

1.6 Thesis outline

This section provides a brief outline of the chapters in this thesis. Figure 1.1 presents a diagrammatic summary of the framework of the research and provides an outline of the components of each chapter. **Chapter One** is an introduction to the thesis and, defines key thesis concepts and aims and an outline of the thesis. **Chapter Two** summarises the existing literature on the importance of calcium and bone health and what is known about the determinants of calcium intake. **Chapter Three** presents a secondary analysis of the most recent National Nutrition Survey to examine the calcium intake of Australian adolescents and young adults from food sources and supplements, as well as the relationship between calcium intake and consumption of food groups.

Chapter Four presents a systematic review on the effectiveness of interventions promoting calcium or dairy intake in young adults. This chapter reports on the efficacy of the interventions and suggestions are made on improving design and reporting of interventions, as well as

intervention strategies that future studies should consider. **Chapter Five** identifies the enablers and barriers to adequate calcium intake. The findings from the focus groups and the practical intervention recommendations formulated based on the analysis of results using the behavioural 'COM-B' system (36) are presented in this chapter.

Chapter Six describes the findings of a survey to gather preferences of young adults regarding intervention messaging, as well as acceptability of mock posts. **Chapter Seven** outlines the development process of a social media intervention (CAN-DO program) designed to improve calcium intakes of young adults. **Appendix 7.4** includes a publication resulting from the development of cooking videos alluded to in Chapter Seven.

Chapter Eight describes the implementation and effectiveness of the CAN-DO program in a three-arm randomised controlled trial. The study measures change in calcium intake (primary outcome), self-efficacy, knowledge, habit and motivation pre and post intervention. The user satisfaction with the intervention and participant experience is also reported via qualitative feedback. The thesis concludes with **Chapter Nine** which discusses the future of the mHealth by the young generation and draws on implications and suggestions for future directions for study that could improve through social media.

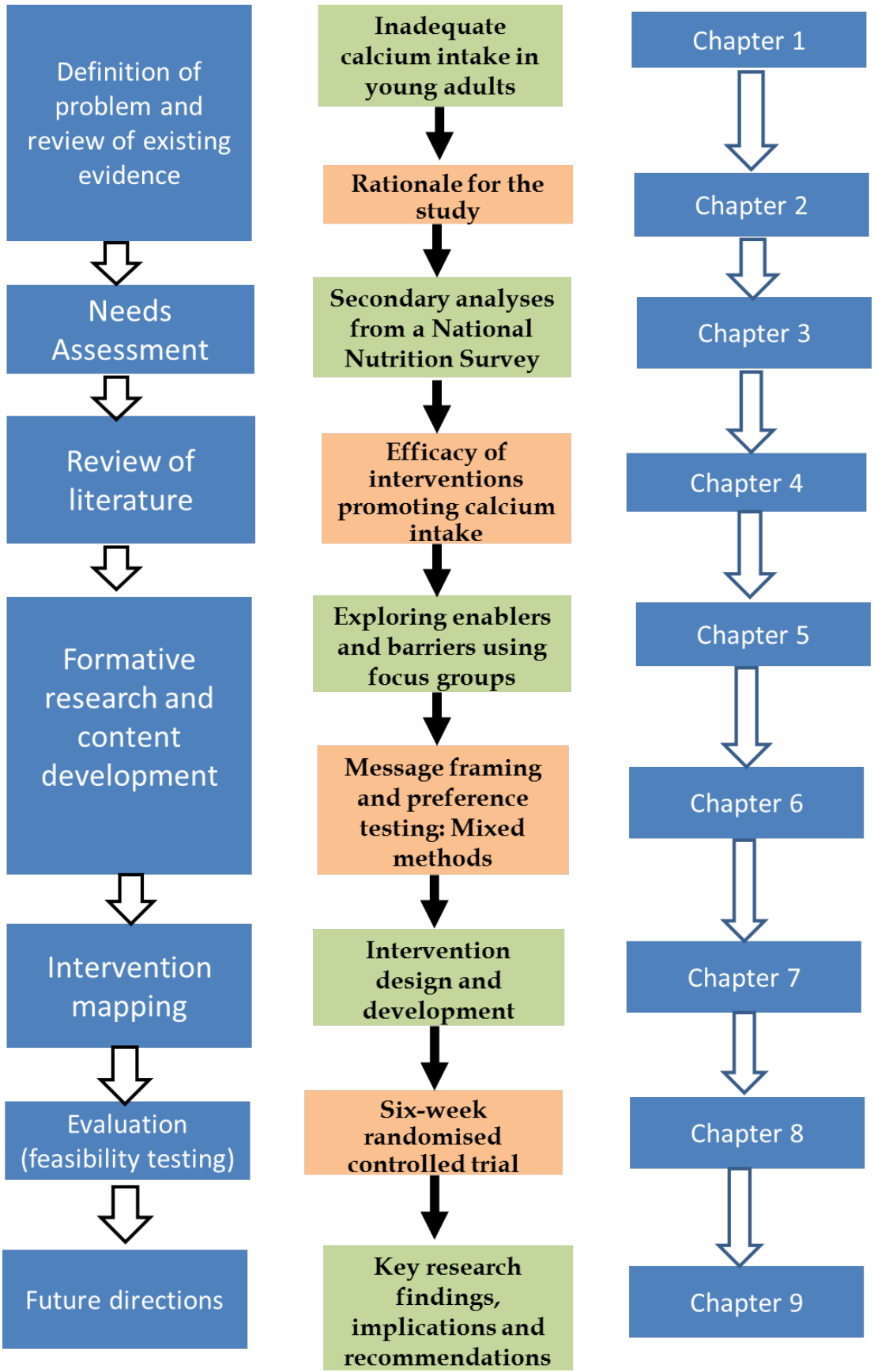

Figure 1.1 A diagrammatic summary of the research aims and an outline of the components presented in each chapter

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1.8 Conclusion to chapter

Calcium is an essential nutrient in attaining optimum peak bone mass during young adulthood. During this period, young adults experience unique challenges that impact their eating habits. The barriers they face need to be addressed in tailored programs and other socioeconomic factors must be taken into account. Modern communication platforms offer a promising solution as they are innovative, relatively low cost and potentially have a greater reach. However, the programs should be tested for their effectiveness prior to dissemination.

Chapter Two

Rationale to the study

2.1 Introduction to the chapter

This chapter contextualises this thesis within the existing evidence base and provides a study rationale (section 2.2 to 2.10).

2.2 Role of calcium in the development of bones and peak bone mass

Calcium is an essential nutrient for the normal development and maintenance of the skeleton, proper functioning of cardiac and neuromuscular function, as well as providing structure and strength to our teeth and bones. Calcium plays a key part in human physiology as it has a central role in mediating a wide array of functions which include muscle contraction and metabolic pathways (1). It is a basic constituent of hydroxyapatite which provides stiffness to the collagen network of mature bone. Insufficient calcium accrual can lead to a sub-optimal peak bone mass which can lead to osteoporosis and fracture (2). Calcium has a role in the prevention of chronic diseases.

The importance of risk reduction of chronic diseases has grown to improve the quality of life and reduce health care load as we have an aging population (3, 4). Osteoporosis is an incurable but preventable chronic disease of the bone. The two crucial lifestyle measures aimed at reducing the risk of osteoporosis include physical activity and nutrition (5). In particular, intake of adequate calcium intake has been shown to be an effective approach for maintenance of a healthy bone status at all life stages, starting from early infancy (6). The adequate intake of calcium across different life stages has been emphasised in the literature (7-9), particularly

during childhood and young adulthood for the development of peak bone mass and for prevention of osteoporosis and osteopenia. Limited research is available on interventions that improve calcium intake among young adults. Previous systematic reviews have focused on children (10), adolescents (11) or the elderly (12). Qualitative research focusing on calcium intake is also lacking (13). No systematic reviews have been conducted on calcium health and bone health in premenopausal women (14) after Welten et al. in 1995 which suggested a positive association between calcium intake and bone mass (15). A few intervention studies reported a consistent positive effect of calcium supplementation of around 1000 mg per day on bone mass (15). A recent review has found that calcium supplementation had the greatest effect in young adults (under 35 years) and reduced their systolic blood pressure by 2.11 mmHg (16).

Osteoporosis is referred to as 'the silent disease' because people are unaware of their risk. It has a high prevalence such that one third of women and 20% of men over age 50 years are affected (17). Osteoporosis commonly results in bone fracture which can reduce quality of life. Osteoporotic fractures result in frequent hospital submissions, a loss of independence and have been associated with an augmented mortality risk (18, 19).

Osteopenia is another bone condition where the bone density is considered to be unhealthy but not as depleted as in osteoporosis (20). The main causes include low calcium intake, low vitamin D and physical inactivity. The term 'osteopenia' essentially describes reduced bone mass and can lead to osteoporosis. It is estimated that 44 million Americans have low bone density and 10 million are affected with osteoporosis (21). In Australia, it is thought to affect around 6.3 million people. The most serious consequence of osteoporosis is a hip fracture which can result in high morbidity and long expensive hospitalisation, mortality or reduced quality of life for the individual. A systematic review of randomised controlled trials examined the efficacy of pharmacological and non-pharmacological interventions and found that treatment with calcium decreased fracture risk (22). There is an increasing need for

osteoporosis management strategies to be actioned, particularly in those who are at high risk. However, the ultimate goal of an effective treatment strategy should be to prevent the fracture in the first place. Preventative measures should be implemented at a public health level. An adequate calcium balance is an important factor in maintaining bone strength but it is not easy to achieve this at a population level. A narrative review published recently has identified key challenges which hinder efforts to improve bone health in populations (23). The challenges that were identified by the authors were related to low levels of public awareness, insufficient access to service and funding for diagnosis, as well as treatment (23)

In order for primary prevention of osteoporosis to occur, it is necessary to understand the factors that influence peak bone mass. Attainment of peak bone mass during youth and young adulthood is a crucial factor to consider (24). It is well known that a higher peak bone mass affords protection against fracture risk later in life (25). Accumulative evidence has shown that the role of nutritional factors in bone health is complex and goes beyond calcium and vitamin D (26). However, 20 to 40% of the peak bone mass acquisition is influenced by modifiable factors which can potentially have a positive or negative effect and in addition to dietary factors include body composition and physical activity (27). Physical activity may influence peak bone mass. A population-based study showed that moderate activity (e.g. walking, cycling or exercising or participation in recreational spots) for at least four hours per week or participation in hard training or sports competitions several times per week increased BMD by up to 11% and 13% in girls and boys, respectively (28). Moreover, results from a retrospective cross-sectional study in pre-pubertal girls showed that global physical activity (rather than activities related to sports per se) was associated with a greater peak bone mass (29). While physical activity has been shown to have a positive effect on BMD and peak bone mass, the optimal dose and the duration of activity needed is unclear (30).The remaining 60-80% of peak bone

mass is determined by genetic factors (31, 32) and sex such that males have a higher peak bone mass and average lumbar vertebral bodies in girls are 11% smaller compared to boys (33, 34).

2.3 Life stages for peak bone mass

On average, bone mass increases by about sevenfold from birth to puberty and a further threefold increase during adolescence (35). Peak bone mass continues to develop until the third decade of life. The peak bone mass generally starts to decline after the age of 30 years and declines further in women during menopause, with an accelerated period of bone loss after menopause for six to 10 years and continues to decline until the end of life.

A Cochrane review in 2003 on postmenopausal women concluded that calcium supplementation had a very small effect on bone density and a trend towards reducing vertebral fractures; but it was not clear if calcium supplementation reduced the incidence of non-vertebral fractures (36). Previous randomised controlled trials have shown that a greater skeletal gain (3% versus 19%) was observed in young individuals after calcium supplementation (24). Therefore, calcium supplementation may be useful for young individuals with a low calcium intake. However, it is unclear what the optimum dose of supplemental calcium should be for boys and girls or for different age or ethnic groups.

There has been an ongoing debate about whether calcium supplementation may lead to an elevated myocardial infarction risk (37, 38), increased pancreatic cancer after vitamin D supplementation (39) or increase the risk of gastrointestinal symptoms and renal disease after supplementation of calcium plus vitamin D (40). However, the evidence is equivocal (30 32,33,34). Due to potential adverse outcomes from supplementation of calcium and vitamin D, it is best to supplement the diet with calcium-rich foods (such as dairy, soy products, deep-water fatty fish and fortified foods) (41).

2.4 Health consequences of low calcium intake

Research in recent years has recognised the importance of adequate calcium intake besides its favourable effects on bone health (16). In 2011, the National Health and Medical Research Council in Australia conducted a review of the evidence to inform the revision of the Australian Dietary Guidelines (42). Statements were made where sufficient evidence was found for dairy foods. The main findings have been outlined in this section. A dose response per serve was used in some instances where one serving of milk was 240 mL, one serving of yoghurt was 240 mL and one serving of cheese was 45 g (42).

The consumption of dairy products, particularly milk was associated with improved bone mineral density (42-45). However, consumption of less than 1 serving of milk per day was not associated with risk of osteoporotic or hip fracture in older adults (mean age 64.3 years) and postmenopausal women (42, 46, 47). A large trial published included over 5000 elderly people with a previous fracture showed no effect of calcium (at levels of 1000 mg) and/ or vitamin D supplements (800 IU daily) on fracture occurrence (48). At present, there is insufficient evidence to promote widespread use of supplementation in the community (49). It would be ideal to conduct long term interventions in men and women stratified by a dietary intake of above and below 500 to 750 mg per day in order to represent a mean daily intake of approximately 300 mg (for the deficient group) and 1000 mg (for the replete group) (49). However, some may question if this is ethical.

While the link between low calcium intake and bone health has been widely known, there is an emerging body of evidence linking calcium intake with other chronic diseases. These studies have largely focused on the effect of dairy foods and have shown improved health outcomes through improved weight control (50) and reduction in risk of metabolic and cardiovascular disorders (51, 52). Consumption of two or more servings of dairy per day have been associated with a reduced risk of ischemic heart disease and myocardial infarction (42, 53, 54) and a

reduced risk of stroke (42, 43, 55). Three servings of low-fat dairy products have been associated with a reduced risk of hypertension (42, 56). Additionally, increased consumption of dairy foods may also be inversely associated with insulin resistance syndrome which is also known as metabolic syndrome or syndrome X (57, 58) and lowering the risk of type 2 diabetes (53, 58, 59).

Calcium intake, particularly a higher consumption of milk has been linked with reducing risk of some types of cancers. Consumption of more than one serve of dairy was associated with a reduced risk of colorectal and rectal cancers (60, 61). Dehghan and colleagues have recently reported their findings on the association of dairy food intake with cardiovascular disease and mortality (62). The PURE study was one of the largest multinational studies to date following over 135,000 participants spanning five continents in 21 countries and showed that dairy consumption was associated with lower risk of mortality and major cardiovascular disease events (62). The findings seem to suggest whole-fat dairy might be beneficial for preventing deaths and major cardiovascular diseases and the authors suggest that "consumption of dairy products should not be discouraged and perhaps even be encouraged in low-income and middle-income countries" (62). The PURE study has a number of limitations (62) and was criticised by others (63, 64). This mainly stems from an assessment of the diet of the participants at baseline only which may not be sufficient given that the dietary intake of individuals may change over the follow-up period (median 9.1 years; IQR 6.4-9.9) (62).

2.5 Foods and dietary patterns associated with calcium intake and bone health

There are several physiological determinants of peak bone mass. The bioavailability of dietary calcium, so important in bone health, is affected by several nutrients and foods including

protein, vitamin D, vitamin K, sodium, phosphate, oxalic acid and phytate. Foods that impact on bone health include, fruit and vegetables that have a positive effect; and soft drinks, alcohol, and caffeine that have a negative effect. The current evidence suggests that a dietary pattern that emphasized the intake of fruit, vegetables, wholegrains, poultry, fish, nuts and legumes, and low-fat dairy products as being beneficial for bone health (65). The Mediterranean Diet, the DASH diet, low sodium diet and the Western diet are dietary patterns that may influence bone health and are discussed below.

2.5.1 Calcium

A diet low in calcium is a risk factor for low peak bone mass. Two large epidemiological studies inclusive of almost 97,000 participants have shown that the risk of fracture was increased in populations with low mean calcium intakes (66, 67). Another cohort study that compares fracture risk in meat eaters, fish eaters, vegetarians and vegans has found that the fracture risk was highest among vegans (68). These studies suggest calcium intake adequacy plays a role in bone health. Overall, those on vegetarian diets appear to be have a similar BMD to non-vegetarians if the calcium intake is adequate and contains good sources of protein in the diet (69).

In order to achieve maximal bone mass, dietary calcium and its absorption need to be sufficient for skeletal growth, and account for obligatory losses in urine, faeces and sweat. While it is known that an adequate calcium intake is needed due to its role in bone mineralisation and skeletal accretion, there are still unresolved questions regarding the biochemical mechanisms (70). More specifically, it remains to be elucidated how much of the dietary calcium the body absorbs but in the estimation of calcium requirements the urinary losses indicate how much of the ingested has been absorbed. The estimate was based on the intake at which the amount of

calcium excreted equals the net amount of absorbed calcium, adding an allowance for insensible losses (71).

Current literature suggests that the intestine absorbs a low percentage which generally does not exceed 35% of the calcium present in food. This works in two ways; passive diffusion when the luminal concentration of calcium is sufficiently high (non-saturable pathway); and active absorption which involves a saturable transport pathway with vitamin D receptors that operates when at low calcium concentrations (72). Parathyroid hormone plays a key role by acting as a sensor, stimulating the production of calcitriol (active metabolite of vitamin D) in the event of a decrease in calcium levels.

There are a number of factors that can affect the intake and absorption of calcium. As dairy provides the largest dietary source of calcium intake in many countries, those with lactose intolerance and following a vegan diet will require alternate options. According to the most recent Australian Health Survey, Cow's milk or dairy was the most reported food causing intolerance (4.5%) (73). However, it is important to note that many people do not undergo a formal diagnosis. An Australian study found that only 4% of their sample were formally diagnosed as being lactose intolerant (74). The prevalence of lactose intolerance can vary greatly between different ethnic backgrounds. A recent review estimated the global prevalence of lactose malabsorption to be 68% (75). Lactose intolerance in adulthood is most prevalent in people of East Asian descent and can affect 90% of adults in these communities (76). It is also common in people with a West African, Middle Eastern, Greek and Italian descent, but most will be able to tolerate small amounts of dairy products other than milk. Other alternatives include lactose-reduced or lactose-free milks and cheeses, as well as lactase enzymes (77).

2.5.2 Vitamin D

Vitamin D plays a critical role in homeostasis of calcium as it facilitates the movement of calcium into duodenal mucosa cells and increases absorption. It has a positive effect on the intestinal calcium absorption, calcium metabolism and bone strength. The importance of vitamin D has been demonstrated in the literature; an American study (data from National Health and Nutrition Examination Survey III) reported 25-hydroxyvitamin D as the dominant predictor of bone mineral density (BMD) relative to calcium intake (78).

However, it is not known how to best screen for Vitamin D and what the appropriate cut offs for diagnosing Vitamin D deficiency or Vitamin D insufficiency (79). Traditionally, supplementation of calcium and vitamin D is most commonly recommended in the elderly (80, 81). Theoretically, supplementation of vitamin D will increase bone density as has been demonstrated in four out of eight randomised controlled trials (82-85). Two other meta-analyses of clinical trials concluded a favourable effect of calcium (1200 mg per day) alone or combined with vitamin D supplementation on reduced bone loss (86) and fracture risk (40, 86, 87). These studies have been conducted in people over 50 (older men and post-menopausal women) and are not relevant to the attainment of peak bone mass during youth. However, studies conducted in the US have found that young adults have an equal to greater risk of vitamin D deficiency than older adults, particularly in winter (88). A cross-sectional study from Denmark reported vitamin D deficiency to be highly prevalent among young adults (89). Little is known about the vitamin D status of Australian young adults; however, studies conducted with broad age groups suggest that vitamin D deficiency affects nearly one third to a quarter of the population (90, 91).

2.5.3 Vitamin K

Vitamin K is necessary to modify a subset of proteins which attaches and transport calcium for specific body functions which include maintenance of skeletal system and teeth. A systematic review conducted with older adults found that supplementation with vitamin K reduces bone loss (92). In recent years, new evidence has emerged that illustrates a role of vitamin K in bone health. It is thought that vitamin K dependent proteins (VKDP) play an important role in regulating mineralisation and vasculature. Clinical studies suggest that increased intake of vitamin K may be a complementary nutrient in supporting bone health and vascular calcification (93). Adequate vitamin K intake is required for optimum bone health as it acts as a cofactor of several bone proteins, osteocalcin being the most abundant. If a person is deficient in vitamin K, osteocalcin is under-carboxylated which is thought to be a marker for bone fragility (94). A study conducted on healthy young adults (18-30 years) and elderly (greater than 65 years) found that the usual dietary intake of vitamin K was not adequate to allow for maximal carboxylation of osteocalcin (95).

2.5.4 Sodium

Sodium intake can also affect calcium requirements due to sodium and calcium being linked in the kidney tubules (96-99). This means that a higher intake of sodium intake may increase calcium excretion. Published literature on sodium and calcium metabolism indicates that the average loss of calcium is about 40 mg per 100 mmol (2290 mg) of sodium (100, 101). Studies conducted with postmenopausal women have shown that both dietary calcium and sodium play a major role in the maintenance of bone health in postmenopausal women (100) and sodium excretion is a significant predictor of calcium excretion (102). A longitudinal study conducted with post-menopausal women reported an increase in bone resorption after following a high sodium diet (103). Findings from a prospective observational

cohort study including almost 70,000 women reported that sodium intake within current guidelines is unlikely to affect osteoporosis in postmenopausal women (104). However, most of the world's population are exceeding the recommended intakes for sodium (105) which places them at risk for development of hypertension, as well as advancing osteopenia (106).

2.5.5 Oxalic acid and phytate

Another important factor for calcium absorption is bioavailability which can vary depending on the individual food and combination of foods. For example, the calcium will be poorly absorbed for foods rich in oxalic acid (such as spinach, rhubarb, swiss chard, beet greens) or phytic acid (such as grains, legumes, seeds, nuts, soy isolates). The fractional absorption of foods high in oxalic acid may be as low as 5%. In comparison, low-oxalate vegetables (such as broccoli and bok choy) have a fractional absorption of greater than 50% (107). Those who are vegetarians, vegan or consume greater amounts of vegetables will have a higher intake of oxalic acid which may reduce calcium bioavailability (108). Additionally, absorption from soy milk is often lower, compared to cow's milk. Calcium absorption from dried beans is about 50% and 10% from spinach, when compared with milk.

2.5.6 Protein

Protein has been identified as being both detrimental and beneficial to bone health, depending on the type and amount of protein (109). The amount of protein in the diet can affect calcium absorption in two ways. Some studies have shown that a high intake of protein can increase urinary calcium excretion (110, 111) (each gram of protein takes out 1 mg of calcium) while diets low in protein are concerning in terms of bone health. This may be due to lowered calcium absorption (112-116); however, the effect of protein on calcium retention is unclear (117, 118). It was previously thought that high protein diets, especially diets high in animal protein resulted in bone resorption and increased urinary calcium excretion (119).

However, higher protein diets have been associated with greater bone mass and fewer fractures when the calcium intake is adequate (109). At present, there are no recommendations for plant protein versus animal protein intake due to the limited evidence of plant protein in relation to detriment of BMD or fractures (120). Overall, the role of protein for bone health appears to be complex and likely to be dependent on the presence of other nutrients.

2.5.7 Fruit and vegetable intake

Fruit intake has been thought to play a role as studies have shown that a greater intake of fruit was associated with higher BMD and lower rates of osteoporosis among middle age and the elderly (121). A small study conducted on adolescents found that girls who consumed higher amounts of fruit had significantly higher heel BMD compared to moderate fruit consumers (122). Another cross-sectional study examined the association between bone mineral status and fruit and vegetable intake in adolescents (16-18 years), young women (23-37 years) and elderly (60-83 years), reported a positive effect on bone mineral status in both younger and older age groups (123). These studies suggest that high intakes of fruit and vegetable may be important for bone health. A recent systematic review examined the relationship between fruit and vegetable intake and bones reporting an association between the increase of at least one serving of fruit and vegetables per day and decrease in the risk of fractures (124).

While intake of fruit and vegetable intake seem to have a protective effect on bone metabolism, the effect on BMD and bone fracture remains unclear (124). However, several mechanisms have been proposed; the classic hypothesis refers to fruit and vegetables slightly altering the basic acid balance in alkaline favour (125). The mild oxidation may increase calcium reabsorption through the renal tubules which in turn would lead to a decrease in bone loss (125). In recent years, the role of fruit and vegetables in oxidation stress has been raised (126) as consumption of fruit and vegetables has been associated with a greater reduction-oxidation

(REDOX) capacity (127). This would supposedly increase the capacity of bone modelling (127) and in turn increase remodelling (128) leading to improved bone repair capacity and reducing bone loss (128). Lastly, some studies have suggested an inverse association between fruit and vegetable intake and chronic inflammatory conditions (129, 130). This is important as chronic inflammatory states are associated with an increased risk of diseases (such as osteoporosis and fracture) (131, 132).

2.5.8. Soft drinks and caffeine

Another factor which hinders calcium absorption is phosphorus which has received considerable attention in recent years (133). Soft drinks (like soda) contain phosphoric acid and can interfere with calcium absorption. Due to the limited number of studies, the effect on long-term bone health is not clearly known as previous prospective studies have only focused on bone mineral density (134, 135) rather than fracture (136). Nonetheless, researchers have put forward plausible mechanisms to explain a potential association between soda and consumption and bone health. It is thought that diets high in phosphorus and low in calcium can reduce serum calcium, stimulate parathyroid hormone and cause bone resorption (137). Moreover, caffeine is present in sodas and has been identified as a risk factor for osteoporosis may cause further interference (138). Finally, sugars are a main ingredient in regular sodas and have been linked with macro mineral homeostasis and bone density in children (139), men (140) and middle aged women (135). Analysis of a cohort study has shown that a greater consumption of soda was associated with modest increased risk of fracture in postmenopausal women (141).

2.5.9. Alcohol and smoking

Alcohol and smoking have direct negative effects on the bone. Limiting alcohol is a crucial step to reach an optimal peak bone mass in young adulthood (142, 143). Epidemiological

studies related to alcohol use and human bone health suggests that chronic heavy alcohol consumption, particularly during adolescence and young adulthood can dramatically affect peak bone mass and may in turn increase the risk the osteoporosis in later life (144). There appears to be a beneficial association between moderate drinking and bone health while heavy drinking is thought to be detrimental for bone health in young adults (145) and older adults (146, 147). It is thought that alcohol affects the bone forming cells (i.e. osteoblasts) and slows down bone turnover (144). However, the specific mechanisms by which alcohol acts on bone and skeleton are poorly understood (148).

Early smoking was associated with lower areal BMD in young men (149) and unfavourable bone geometry and density in healthy males (aged 25-45 years) (150). A similar association was reported for female twins (27-73 years) where a packet of cigarettes daily throughout adulthood was thought to cause a reduction in bone density by 5 to 10 percent (151).

2.5.10 The Mediterranean diet

The Mediterranean diet was found to improve dietary calcium utilisation among male adolescents (152) and was positively associated with better bone mass in pre-menopausal women (153). It was also found to be associated with higher BMD and lower fracture risks (154). While this may be due to the combined synergistic effects of is components, adherence to the Mediterranean diet is thought to be a protective factor in the maintenance of bone mass and preventing bone fracture (154). Further studies are needed as there is a paucity of evidence to understand the relationship between the Mediterranean diet and musculoskeletal outcomes across children, adolescents and adults (155).

2.5.11 The DASH diet and low sodium diet

It thought that the DASH diet and reduced sodium intake may have beneficial effects on bone health. The DASH diet was found to significantly reduce markers of bone turnover (156) and calcium metabolism in adults (157). A low sodium diet was found to significantly decrease sodium and calcium excretion which suggests that a low sodium diet may have benefits for skeletal health in post-menopausal women (158).

2.5.12 The Western Diet

The Western Diet is characterised by intake of soft drinks, fried foods, meat and processed foods, sweets and desserts, and refined grains. A high adherence to the Western diet has been associated with a high intake of fat, protein, refined carbohydrates, sodium and phosphorus (159). High intake of sodium is associated with calciuria which can increase bone remodelling and bone loss (160). High intake of phosphorus is thought to be detrimental for bone health due to the disruption of the calcium to phosphorus ratio (159). Overall, the Western dietary pattern featuring some aspects of an unhealthy diet is likely to be associated inversely with bone health (65).

2.6 Australian recommendations, rationale and revisions

The recommendations for calcium intake vary throughout the life cycle and are highest at the time of bone formation and in older people and provided in a range to cover for factors mentioned above. It is important to note that the recommendations for calcium intake vary worldwide (see 2.7 for global recommendations).

For adolescents aged 14 to 18 years, the amount of calcium recommended is increased to 1050 mg/day (EAR) and 1300 mg/ day (RDI); while for adults aged 19 to 50 years, the EAR is 840

mg/ day and the RDI is 1000 mg/ day (71). Most of the research into requirements comes from studies with dairy products, rather than other calcium sources per se. This is because dairy products tend to be the main source of calcium in many countries around the world including Australia (161-163). In Australia and New Zealand, approximately 40% of the calcium comes from non-dairy sources in adults (71). Dairy products such as milk, cheese and yoghurt are an important source of obtaining essential micronutrients which include calcium, riboflavin, phosphorus, potassium, magnesium and zinc. Consumption of dairy products has been associated with reducing the risk of osteoporosis, metabolic syndrome and other chronic disease such as hypertension, obesity, heart disease and colon cancer. However, dairy foods have become rather controversial in recent years as to whether low-fat or full-fat options make a difference to the risk of cardiovascular disease (164). There are a variety of components that have been proposed in the literature which includes bioactive lipids (165), milk derived bioactive peptides (166) and type of dairy (fermented vs. unfermented) (167). Beneficial effects have been observed for fermented dairy products (such as sour milk products, cheese and yoghurt) regardless of whether the fermented dairy is low-fat or full-fat (168). The mechanistic pathways for the observed protective effect of full-fat dairy are yet to be elucidated. Additionally, it is also important to consider the whole dairy food matrix as recent evidence suggests that full-fat dairy foods do not cause weight gain and fermented dairy consumption (including cheese) is linked to lowering cardiovascular risk (169). Thus far, studies suggest that whole dairy products have a greater beneficial effect on health compared to single dairy constituents (170). Future studies should consider the evidence on the effect of whole foods, as well as the effects of the individual nutrients.

Overall, milk is thought to have a neutral effect on cardiovascular outcomes while fermented dairy products (such as yoghurt, kefir and cheese) may have a positive or neutral effect (164). Given the current evidence, the new advice from the Heart Foundation in 2019 has removed

the restriction for healthy Australians on eating full-fat milk, cheese and yoghurt (171). However, individuals with high cholesterol or heart disease are recommended to have unflavoured reduced-fat milk, yoghurt and cheese (171).

2.7 Global recommendations and intake

As dairy products are a primary contributor to calcium intake, the adequacy of dietary calcium correlates strongly with the geographic variations in milk consumption (172). There are enormous variations in intake between regions, cultures and individuals around the world. It is thought that populations with a low intake of dairy have developed adaptive mechanism that enable them to develop and maintain good bone health at calcium intakes that are far below the RNI in developed countries (172). Thus, setting a global RNI may not be appropriate.

A systematic review reported that lactose malabsorption is widespread, varies greatly between different regions and estimated to be present in around two-thirds of the world's population (75). It is particularly common in some Asian countries. For this reason, intakes in East Asia are much lower than South Asia (172). The differences in intake can be linked to the prevalence of lactase persistence genes (173). Lactase persistence is defined as a genetic trait that allows milk to be consumed beyond the weaning period without experiencing gastrointestinal discomfort. For this reason, there are significant regional differences in dairy representation. It is strongly emphasised in North America, the Near East and Europe and is portrayed as a separate food group in nearly all countries (174). In contrast, fewer countries in Africa, Asia Pacific and Latin America/ Caribbean region depict dairy as a separate food group. In much of Africa, there are other limitations such as cost, absence of refrigeration and poor availability (172).

There are slight variations in the dietary reference values for calcium, depending on the reference guidelines. For adults aged 19 to 50 years, the Dietary Reference Intakes in America and Canada is 800 mg/ day for EAR and 1000 mg/day for RDA (175). The dietary reference in the UK is 525 mg/ day or EAR and 700 mg/ day for RNI (176). The FAO/WHO is 840 mg/ day for EAR and 1000 for RDA (177). For young adults aged 19 to 24 years, the European (EFSA) for calcium is 860 mg/day for average requirement and 1000 mg/day for population reference intake (178).

In recent years, the International Osteoporosis Foundation took the initiative to conduct a systematic review of the dietary calcium intake around the world to find the most representative data from each country (179). Data for calcium was available for 74 countries. It was found that most surveyed countries in South, East and Southeast Asia including China India and Indonesia have low dietary calcium intake (<400 mg/day) while countries in Africa and South America have moderate calcium intake (400-700 mg/day) (179). Interestingly, the countries with mean calcium intake greater than 1000 mg/ day were all in Northern Europe (179). In comparison, the dietary intake of calcium for Australia was found to be 805 mg based on results from the most recent National Nutrition Survey that included a nationally representative data sample of 9938 people (179). However, it must be noted that these results show data for all adults over the age of 19. The inadequacies present in Australian population are observed in other parts of the world (179). Survey data from New Zealand has reported that a third of respondents consumed less than a glass of milk per day and non-consumption was higher among young women (180).

2.8 Health promotion for osteoporosis prevention

2.8.1 Closing the gap between current intake and national recommendations

Results from the most recent National Nutrition and Physical Activity Survey (NNPAS) 2011-12 survey has indicated that only 10% of the Australians are meeting the recommendations for dairy foods and calcium-rich alternatives (181). In Australia, dairy is the second most under-consumed food group (after vegetables). Adolescents, young adults and the elderly are most at risk. Results from the Australian Health Survey 2011-12 reported that milk products and dishes provided 42% of calcium (21% from milk, 9.6% from cheese and 4.8% from yoghurt) (73). The results are similar to the National Nutrition Survey from 1995 where dairy products accounted for more than half of the daily calcium intake, with 30-45% coming from milk and 10% from cheese (182). Additionally, the survey results indicated that dairy products had a much larger contribution to children's calcium intake compared to adults (182).

A study that disaggregated the food intake and compared the intakes between the two surveys (1995 and 2011) reported an increase in intake of dairy products for adults (19 years and over) while a decrease was observed for younger Australians (2 to 18 years) (183). The findings are consistent with a longitudinal observational study on Australian adolescents (14-17 years) as a decrease in dairy intake was reported for adolescents between the years 2003 and 2006 (184). Young adults are not faring any better in the States as a prospective population-based study has found that two-thirds of females and more than half of males had calcium intakes that were lower than recommended and a reduction in calcium intake was reported for calcium intake during the transition from middle adolescence (high school) to young adulthood (185).

There have been numerous population-based approaches to promote bone health, however formal evaluation results are not available for all programs (186). Several notable campaigns in America included The National Bone Health Campaign (tag line: Powerful Bones, Powerful Girls™) for girls aged 9 to 12 years; Living Healthy: The Asian American

Osteoporosis Education Initiative targeted to Asian-American women; Michigan Department of Community Health Osteoporosis Program which included in-school education, community screening and a falls prevention program; Project Healthy Bones New Jersey Department of Health and Senior Services for older adults; Building Community Capacity and Group Support in Bone Health in North Carolina and Milk Matters Campaign which used a multimedia approach and was directed particularly towards young people (186). The US *Got Milk?* campaign gained a lot of attention but failed to show a corresponding increase in milk sales despite having a budget of $110 million (187). In recent years, there have not been government initiatives to increase consumption in Australia. The industry body, Dairy Australia has developed an online hub for primary school teachers offering a range of resources (such as PDF's, animations and videos) to highlight the farm to plate process and the importance of including dairy foods, as part of a balanced diet (188).

The pressing issue at hand is finding a solution that is innovative and engaging that meets the needs of the target populations. A 'one size fits all' approach should not be employed as previous research indicates that generic messages do not resonate with the audience (189). Therefore, targeted public health initiatives that are engaging for adolescents and young adults. are needed in Australia to improve their intakes.

2.9 Emerging adulthood, dietary intakes and implication for calcium intakes and nutrients associated with bone health

Improving dietary behaviours in young adulthood can have a major impact on health outcomes. While the risk-taking behaviour of young adults are typically associated with illicit drugs or sexual behaviour (190, 191), a scoping review has revealed that dietary behaviour can also be an act of risk-taking (192). Young adults are unable to comprehend the effect current nutrition

and diet can have on health later in life (192). They have been labelled as the "young invincible" as they are a particularly challenging population to instil healthy behaviours as they tend to undertake risky behaviours and do not see the longer implications of these behaviours, such as consuming a poor diet (193).

However, the intriguing question is who must take responsibility for optimising a diet to enable attainment of the peak bone mass in young adults. Although physicians and specialists play an important role in diagnosing underlying osteoporosis and subsequent treatment, it is up to the individuals and organisations to act on early prevention. Young adults themselves and their parents, general practitioners and governments should be responsible for the lifestyle measures. The first step is to create awareness on the health consequences of low calcium intake including the burden of fracture risk in later life. The next step will be creating education programmes for adolescents and young adults. However, implementation of primary prevention programmes can be difficult, but certainly worthwhile as prevention is better than cure as the old adage goes (194). Given the widespread prevalence of osteoporosis in later life a prevention program during young adulthood requires wide reach. However, young adults are a difficult-to-reach population with relatively low healthcare utilisation, which makes it difficult to disseminate information in this age group (195-197).

2.10 Harnessing technology for solution generation

2.10.1 Using m-health based technology

The use of internet in Australian homes has risen from 3.4% to 86% from 1996 to 2015 (198, 199) and 95% of young adults own a smartphone. A recent study has reported that the main users of health apps were individuals who were younger, more educated, reported excellent health and a higher income (200). This is particularly relevant for young adults who are the

highest users of smartphones and social media (201). Seventy-seven percent of young adults consult their smartphone for health facts (202). The high penetration of smartphone ownership and usage of digital media has the potential to be harnessed by health professionals in the delivery of behaviour change interventions. The WHO refers to the term mHealth (mobile health) as the use of smartphones in a public health setting (203). Electronic health or eHealth describes the use of the internet to aid with public health practice (204).

Following the rise in these technologies has been the introduction of e- and m-health interventions which employ the web, applications and texting to deliver health messages and instil behaviour change through education, self-monitoring, tailored feedback and other means (205, 206). Studies have shown that interventions that allow for self-management delivered remotely may be as effective as those delivered in person (207, 208). It is believed that a modern platform using smartphones and social media could be particularly useful for younger generations as they use social media as their primary information sharing resources.

2.10.2 Use of mobile technology among young adults

Young adults spend a majority of their waking hours with technology. The current generation of young adults (GEN Y/Z) are technologically savvy and heavy users of digital platforms (i.e. social media and smartphones) for communication more than any other age group (209). In 2016, 95% Australian young adults aged 18 to 34 years owned a smartphone and 91% used their device in social networking (209, 210). In 2015, it was reported that 75% of this age group also used their smartphones to obtain information about a health condition (211). Moreover, qualitative research has shown that the use of social media allowed young adults to expand their food choices through creating access to a variety of recipes, provide a venue to showcase how young adults eat or prepare food and distract young adults from making positive food choices (212).

Incorporating e/mhealth interventions could expand the delivery of health promotion beyond the conventional boundaries and increase cost-effectiveness (213). The current literature supports cost-effectiveness of mHealth interventions and has reported high rates of positive costing outcomes using mHealth interventions compared with usual care and other comparators (214). However, it must be noted that many studies included in the systematic review did not report on all recommended economic outcomes and lacked a comprehensive analysis (214).

Modern communication technologies that use social platforms, Short Messaging Service (SMS), graphics and videos are likely to be more appealing to young adults compared to traditional modes such as face-to-face or group education (215, 216). Due to the aforementioned reasons, social media is a ripe and informal venue for disseminating health information to young adults (212). Social media may provide certain advantages for public health interventions due to being a low-cost platform and its potential for a greater reach. Nevertheless, a systematic review conducted on the use of social media (diet and exercise interventions) has shown low levels of participation and adherence; and studies do not show a significant difference between groups in key outcomes (217). While there is little evidence at present to show that social media interventions are highly beneficial, it must be noted that there were a very limited number of studies at the time of the review Social media is an ever-changing technology so continuous research is needed. A more recent systematic review conducted exclusively on young adults (18-35 years) has found that the majority of interventions were not effective at improving outcomes (such as weight, BMI or dietary intake) when compared to control groups (218). The review was conducted using a mixed-methods approach and the aims included describing how young adults use social media; evaluating engagement metrics; understanding whether engagement with social media can improve nutrition outcomes; exploring the functions of social media and understanding how young adults use social media (218). Since the majority of interventions included multiple

components, it was difficult to attribute the effectiveness of social media which was a common component (218). The engagement with social media varied greatly and ranged from 3 to 69% (218). While young adults identified that social media was useful for delivery of information and encouragement of learning, several studies included in the review reported social media to be the least used and lowest ranked component of the intervention (218). Young adults reported that posting information related to their weight was socially undesirable which may explain the low levels of engagement in some of the included studies (218). Overall, the review revealed that most young adults are conducive to receiving healthy eating and recipe tips on social media; and identified social media as a platform for providing social support (218). Although these results are somewhat promising, future research is needed to understand how to best engage on different social media platforms and for different dietary behaviours. The effectiveness of interventions for improving calcium intake of young adults has not yet been documented and will be ascertained in this thesis.

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2.12 Conclusion to chapter

Young adulthood is an important developmental time period for establishing lasting healthy behaviours. Calcium has a role in the prevention of chronic diseases and is an important nutrient for bone health. It is important to optimise the peak bone mass of young adults to prevent osteoporosis in later life. Due to the unique challenges faced by young adults, interventions need to take these life stage dependent factors into account. Social media offers a promising avenue for intervention delivery as it is relevant for this age group.

Chapter Three

Low calcium intakes among Australian adolescents and young adults are exacerbated by higher consumption of discretionary foods and beverages

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3.1 Publication details

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3.2 Author contribution

I Anika Rouf (the candidate) drafted the manuscript. ZS, AR, AG and MA-F contributed to the data analysis and interpretation of the results. All co-authors have provided input to the content of the final published manuscript.

3.3 Introduction to the chapter

It is important to understand the national data by sex, geography and SEIFA before designing an intervention. In Australia, the most recent NNPAS was conducted 2011-12. This included an assessment of dietary intake which included collection of detailed data on quantities consumed as discrete foods and in mixed dishes by occasion. This chapter aims to use the data from the 24-hour dietary recalls to examine calcium intakes in Australian adolescents and young adults. The analyses examine the calcium intakes, identify the major food sources contributing to calcium intake and examine demographic, anthropometric and dietary factors associated with calcium intake.

3.4 Abstract

Objectives: Calcium is an essential nutrient required for peak bone mass growth during adolescence and into young adulthood. The aim of this study was to examine the calcium intake of Australian adolescents and young adults from both food sources and supplements; and the relationship between calcium intake and intake of food groups.

Methods: Dietary data from 770 adolescents (14-18 years) and 774 young adults (19-25 years) from the 2011-12 National Nutrition and Physical Activity Survey were used. Analysis of covariances were conducted to identify associations between calcium intake and consumption of food groups.

Results: For adolescents, 83% of males and 95% of females did not meet the Estimated Average Requirement (EAR); whereas for young adults, 69% of males and 83% of females failed to meet the EAR. Food sources contributing to calcium intake were similar across age groups and sex. The largest contributors included regular milk (15-24%), cheese (10-12%), refined low-fibre bread (10%), and low-fat milk (79%). For both age groups, the lowest

consumers of calcium were the poorest consumers of dairy products and the highest consumers of discretionary food choices and alcoholic beverages. A higher consumption of calcium was associated with a higher intake of dairy products and lower intakes of meat and alternatives and all discretionary choices.

Conclusions: Calcium intake among Australian adolescents and young adults remains below recommendations, particularly in females. A higher intake of calcium was associated with a better dietary pattern. Further investment in interventions is indicated.

3.5 Introduction

The period between adolescence and young adulthood is one of nutritional vulnerability, including high requirements for calcium. Calcium assists in the growth of peak bone mass, 90% of which is achieved from late adolescence to the age of 20 years [1]. Adolescence is a critical time to address food intake as children start gaining independence from their parents, which can result in an increased intake of meals prepared outside the home and a lower consumption of foods from the recommended food groups [2]. The latest Australian Health Survey revealed that only 1 in 10 Australian adults are consuming the recommended amounts from the dairy and alternatives food group, which includes milk, yogurt, cheese, and alternative sources of calcium [3]. Although calcium-rich foods and beverages are commonly consumed by children in Australia [4], statistics suggest that the intake of the milk food group decreases during adolescence [5,6]. Dairy products provide the largest source of dietary calcium in Australia as well as in many other countries such as the United States[7], the United Kingdom[8], and most of northern Europe[9]; and are not easily replaced with other foods in the diet to meet nutrient requirements, as shown by nutrient modelling[10] and nutrient profiling [11]. Overall, the available evidence suggests that milk and other dairy products are

important contributors to nutrient intake, diet quality, and bone health; and may provide protection against prevalent chronic diseases [12,13] such as ischemic heart disease, stroke, hypertension, type 2 diabetes, obesity, and metabolic syndrome [14-23], as well as reduced risk for colorectal cancer [24-26]. Females are considered to be an at-risk group for insufficient calcium intake [27]. This is concerning as low bone density is a problem, especially among postmenopausal women [28]. Previous interventions in promoting dairy products and calcium have not been very successful in adolescents and young adults [29,30]. To support this age group, it is necessary to delve into the food habits of youth and young adults, and to identify the main contributors to calcium intake and sociodemographic groups who may be at high risk. Although the Australian Bureau of Statistics (ABS) has conducted analyses of the most recent national survey, the analyses did not disaggregate the mixed dishes into their component ingredients, nor study relationships with food group intakes. The aim of the present study was to conduct secondary analyses of the National Nutrition and Physical Activity Survey (NNPAS) and to examine the relationship between calcium intake and consumption of the recommended and discretionary food groups.

3.6 Methods

3.6.1 Data collection

The data analyzed in the present study were collected as part of the 2011-2012 NNPAS conducted by the ABS from May 2011 to June 2012 throughout Australia using nationally representative subsamples. Ethics approval for the survey was obtained from the Australian Department of Health and Ageing Departmental Ethics Committee in 2011. A detailed description of the survey methods and data collection has been reported elsewhere [31]. In brief, a total of 12,154 respondents were interviewed face-to-face to collect demographic,

anthropometric, and dietary data. Food and beverage consumption data were obtained by trained staff using a multiple-pass 24-h computer-assisted person interview. A second-day recall was conducted by telephone in a subsample of 64% of respondents. Adult respondents were interviewed in person, and children between the ages of 15 and 17 y were interviewed if permission was granted by parent or parental proxy. For 14 year olds, the parents were proxies as reported previously [32]. The estimation of food, beverage, and nutrients were obtained from the AUSNUT 2011-2013 food composition database, which was developed specifically for the NNPAS [33]. The present study focused on the calcium intake of adolescents ages 14 to 18 y and young adults ages 19 to 25 years.

3.6.2 Assessment of calcium intake

All intake data from mixed dishes were disaggregated by estimating the individual food components from a mixed dish using the AUSNUT 2011-2013 recipe file [33,34]. Previous analyses had not conducted this analysis. Foods were classified according to the four-digit food code from the Australian Dietary Guidelines database compiled by Food Standards Australia New Zealand [35]. Calcium intake was obtained from all foods, beverages, and supplements using AUSNUT 2011-2013. To establish the proportion of the population taking supplements, respondents were coded as “consuming” and “non-consuming” based on self-report. Throughout this study, “calcium supplement” referred to any supplement containing calcium, including multivitamins that contain small amounts of calcium. The usual intakes of respondents' total energy and calcium intake were estimated from two 24-h recalls using the Multiple Source Method (MSM) where a Box-Cox transformation was applied to normalize the data before estimating the usual intake [36]. Women who were pregnant or breastfeeding were excluded due to their different nutrient requirements.

3.6.3 Comparison to national recommendations

The usual calcium intakes were compared with the Estimated Average Requirement (EAR) of calcium for adolescents ages 14 to 18 y (1050 mg) and young adults ages 19 to 30 y (840 mg) [37].

3.6.4 Food groups

The food categories used in this analysis were the recommended food groups that included grain (cereal) foods; vegetables and legumes/beans; fruit; lean meats and poultry, fish, eggs, tofu, nuts and seeds and legumes/ beans; and milk, yogurt, cheese and/or alternatives [38,39]. For simplicity purposes, the categories from the five food groups are referred to as grains, vegetables, fruit, meat and alternatives, and dairy and alternatives throughout. Discretionary foods were categorized as solid choices (cakes, biscuits, fast foods), liquid choices (soft drink, sugar-sweetened beverages), and alcoholic beverages [31,40].

3.6.5 Demographic covariates

Demographic factors collected included weight status (underweight, normal range, overweight, or obese), country of birth (born in Australia, English speaking countries, or other), geographic location (major cities, inner regional, or other) and highest year of school completed (year 12 or equivalent, year 11 or equivalent, year 10 or equivalent, year 9 or equivalent, year 8 or below). Socio-economic quintiles were derived from the Socio-Economic Index of Disadvantage for Areas (SEIFA), where the most disadvantaged areas were classed as the first SEIFA quintile [40]. Other self-reported variables included current smoking status(yes/no), physical activity recommendations met (yes/no), and use of calcium supplements (yes/no). The methodology used to collect this data has been described elsewhere [31].

3.6.6 Timeline of calcium and food intake

The mean calcium intakes for each hour of the day were calculated and mean contribution from each of the food groups was determined. These were used for a graphical representation of the data.

3.6.7 Statistical analyses

Descriptive statistics were tabulated to display sample characteristics. Usual calcium intake (food sources and supplements) using two dietary recalls were reported in this study to estimate proportions meeting EAR. As dietary misreporting has been identified in the 2011/2012 NNPAS [41], a categorical variable was created to classify under-reporters, plausible, and over-reporters. Energy reporting status was categorized based on the Goldberg cut-offs (energy intake to basal metabolic rate of ≤0.87 for under-reporters, 0.88-2.66 for plausible reporters, and ≥2.67 for over-reporters) [42]. The usual calcium intake of respondents was categorized into quartiles to assess differences in food group intakes. Calcium intake was calculated as calcium density in mg per 1000kJ to adjust for energy intake. For continuous variables, a one-way analysis of covariance (ANCOVA) was used for determination of linear trends. A post-hoc test (Bonferroni) was applied to locate the group differences. All statistical analyses were performed using SPSS for Windows 22 software (IBM, Armonk, NY USA). $P<0.01$ was considered statistically significant for all tests due to the large number of comparisons.

3.7 Results

3.7.1 Comparison to national recommendations

The sample included 770 adolescents and 774 young adults distributed across sex and SEIFA. Approximately 18% of the respondents were classed as under-reporters and 1% to 4% were classed as over-reporters for both age groups. The demographic characteristics of the sample stratified by age and sex are shown in Table 3.1. For adolescents, 83.1% of boys and 94.8% of the girls had calcium intakes below the EAR. For young adults, 68.9% of males and 82.9% of the females were consuming below the EAR.

3.7.2 Calcium intake and food sources

Table 3.2 shows nutrient and food group data stratified by age and sex for the five food groups and discretionary choices. The mean (SD) usual calcium intakes for males were 738±303mg and 737±342mg for adolescents and young adults, respectively. For females, the usual intakes were 583±258mg and 621±176mg for adolescents and young adults, respectively. The proportion of the population using calcium supplements was 7.1% and 11.8% for adolescents and young adults, respectively; and accounted for <1% of the total calcium intake (Table 3.2). The main food sources of calcium were ranked as shown in Figures 3.1 and 3.2. For both population groups, the top contributors included regular milk, cheese, bread, and low-fat milk. Fewer young adults drank milk (contributing 16-18% of total calcium) compared with adolescents (contributing 20-24%). Calcium alternative beverages were consumed by a larger proportion of young adult females compared with the other groups (Figure 3.2). A minor contribution to calcium intake was made by fish and seafood, dairy snacks, legumes, and tofu.

Table 3.1 Sample demographic characteristics from the National Nutrition and Physical Activity Survey 2011–2012; proportions (%) by age and sex

		Both age groups		Adolescents		Young adults	
		% Males (n= 786)	% Females (n= 758)	% Males (n= 403)	% Females (n= 367)	% Males (n= 383)	% Females (n= 391)
Weight status	Underweight	4.7	5.5	5.2	5.7	4.2	5.4
	Normal range	60.0	62.8	68.7	67.6	51.5	58.6
	Overweight	25.3	18.3	20.1	17.6	30.3	18.9
	Obese	10.1	13.4	6.0	9.1	14.0	16.9
Country of birth	Australia	82.8	86.3	88.8	89.6	76.5	83.1
	Main English speaking countries†	5.1	5.9	4.5	5.7	5.7	6.1
	Other	12.1	7.8	6.7	4.6	17.8	10.7
Remoteness	Major cities	65.9	64.2	59.3	60.5	72.8	67.8
	Inner regional	18.6	20.7	21.3	20.2	15.7	21.2
	Other	15.5	15.0	19.4	19.3	11.5	11.0
SEIFA‡	Lowest 20%	17.0	18.2	17.1	12.5	17.0	23.5
	Second quintile	18.8	19.1	17.6	20.7	20.1	17.6
	Third quintile	19.6	20.2	19.4	22.6	19.8	17.9
	Fourth quintile	18.2	16.6	18.1	19.3	18.3	14.1
	Fifth quintile	26.3	25.9	27.8	24.8	24.8	26.9
Currently smokes	Yes	13.7	13.6	6.90	4.1	20.9	22.5
Physical Activity	Met recommendations	Not measured for adolescents		Not measured		57.7	50.9
Misreporting‡‡	Under-reporters	15.3	20.1	15.6	18.0	14.9	22.0
	Plausible reporters	70.2	64.4	66.5	60.5	74.2	68.0
	Over-reporters	3.7	1.3	3.2	1.6	4.2	1.0
	Could not be classified	10.8	14.2	14.6	19.9	6.8	9.0
Calcium intake	Inadequate intake	76.0	88.7	83.1	94.8	68.9	82.9

†Main English-speaking countries include Canada, Ireland, New Zealand, South Africa, United Kingdom and The USA; ‡ SEIFA. Socio-economic indexes for areas developed by ABS that ranks Australia based on socio-economic disadvantage; ‡‡ Misreporting. Under-reporters (energy intake vs. Basal Metabolic Rate <0.87), plausible reporter (energy intake vs. Basal Metabolic Rate ≤0.87 to ≥2.67), over-reporters (energy intake vs. Basal Metabolic Rate ≥2.68) and could not be classified if insufficient data was provided by respondents.

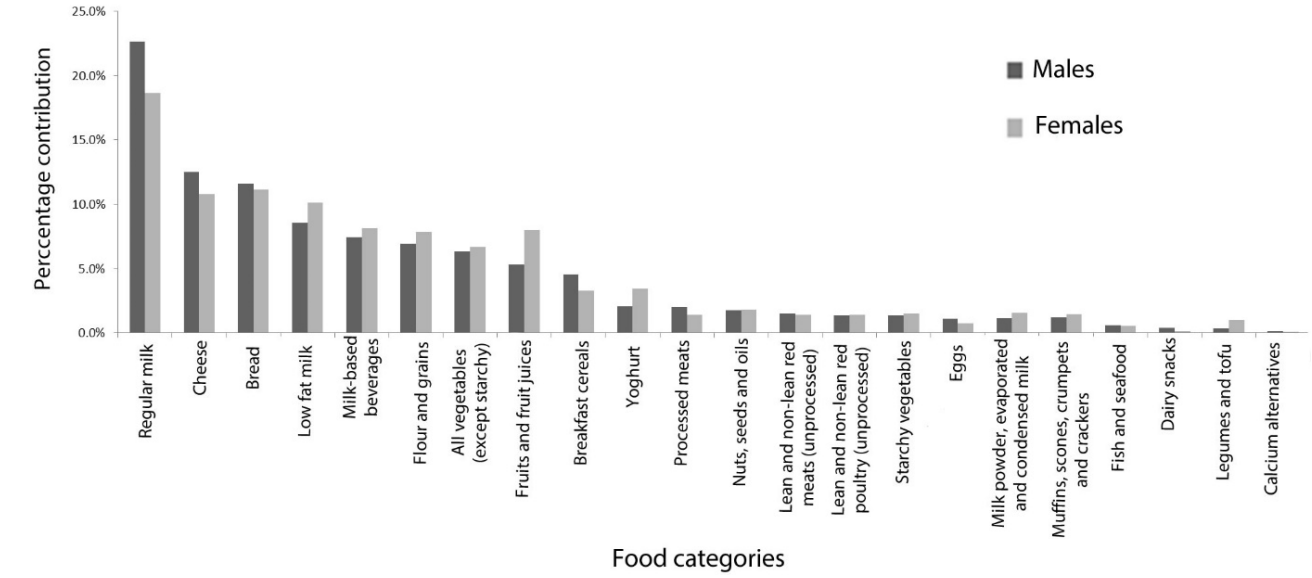

Figure 3.1 Percent contribution of calcium intake among Australian adolescents aged 14-18 years from major food groups.

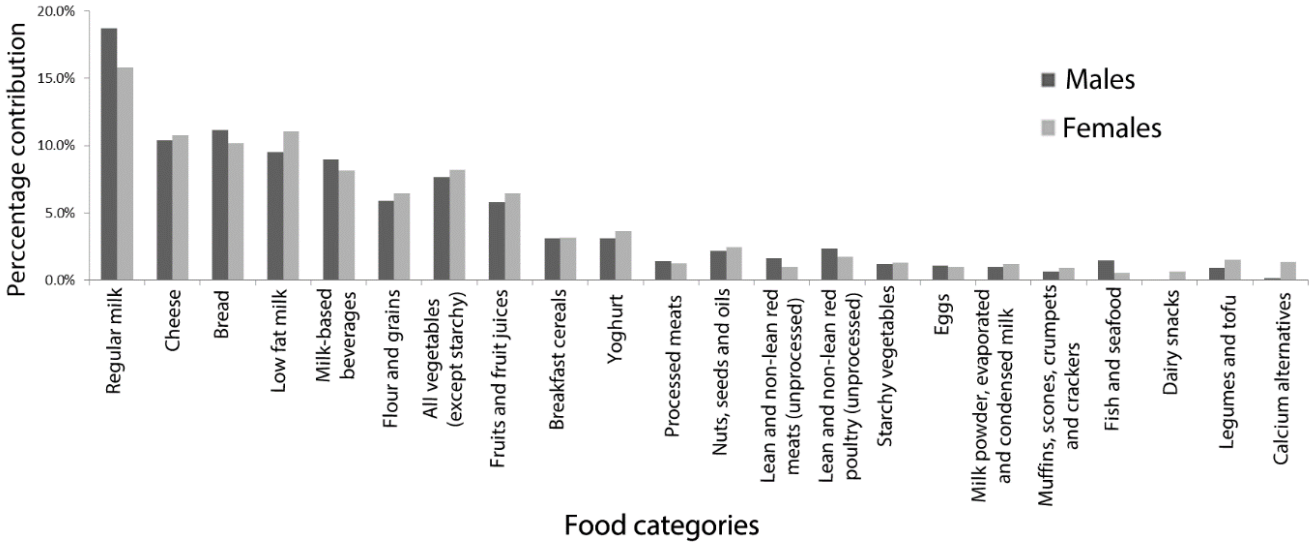

Figure 3.2 Percent contribution of calcium intake among Australian young adults aged 19-25 years from major food groups.

Table 3.2 Usual dietary intakes† of adolescents and young adults from the National Nutrition and Physical Activity survey 2011-12: Mean ± SD by age and gender.

	All ages		Adolescents		Young adults	
Mean ± SD	**Males (n= 786)**	**Females (n= 758)**	**Male (n= 403)**	**Females (n= 367)**	**Males (n= 383)**	**Females (n= 391)**
Energy intake (kJ)	8102 ±2465	6103±1744	7892±2195	6104±1766	8322±2705	6103±1725
Calcium intake (mg)	738±323	603±259	739±304	583±259	738±342	622±177
Calcium supplement (mg)	11.3±69.3	11.6±62.8	7.9±63.3	5.9±33.6	14.8±74.9	16.9±80.9
Grains (g)	214±96.3	164±73.1	205±88.6	168±71.5	224±103	160±74.5
Vegetables (g)	152±70.2	142±62.9	143±65.2	136±62.4	162±73.9	148±63.0
Fruit (g)	157±124	163±115	160±115	171±117	153±132	156±113
Dairy and alternatives (g)	239±173	195±147	244±170	196±155	234±176	195±138
Meat and alternatives (g)	139±64.6	100±44.7	127±56.2	97.5±45.4	151±70.3	103±44.0
Liquid discretionary (g)	308±224	216±1734	316±227	213±170	301±221	218±177
Solid discretionary (g)	196±115	152±75.6	195±100	160±81.0	197±128	145±69.6
Alcoholic beverages (g)	151±413	45.1±154	48.6±242	6.4±67.5	258±516	81.5±198

†Usual intake was determined using two 24-hour dietary recalls. The food groups are in accordance with the recommended five food groups from the Australian Dietary Guidelines (full description included in methods).

3.7.3 Dietary and demographic characteristics

Tables 3.3 and 3.4 present the dietary characteristics by quartiles of usual calcium intake (energy adjusted) for adolescents and young adults, respectively. A higher calcium intake was associated with a lower intake of meat and alternatives, solid and liquid discretionary choices, and alcoholic beverages but a higher intake of dairy products and supplements. Fruits and vegetable intake did not differ between quartiles. A higher intake of calcium was associated with lower intake of energy and grains for young adults only. No differences in calcium intake according to plausible or mis-reporting of dietary intake were found (Supplementary Table 3.1). Some differences in calcium intake were found for those who were born in Australia (higher intake) compared with those born in other countries (P=0.016 for adolescents; P=0.052 for young adults). Attainment of education was significantly associated with calcium intake in young adults (P=0.01) but not for adolescents. For young adults, smoking was significantly associated with lower calcium intake.

Table 3.3 Dietary characteristics of adolescents (n=770) by quartile of usual calcium intake from the National Nutrition and Physical Activity survey 2011-12, based on two-day data and adjusted for energy.

Quartile (Calcium density mg/ 1000 KJ)	**Q1 (32.1-71.6)**	**Q2 (71.6-91.5)**	**Q3 (91.5-111.6)**	**Q4 (111.6-241.8)**	**P-Value†**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Energy (kJ)	7348±2494	6856±1976	7025±2212	6926±2025	0.127
Grains (g)	200±100	183±77.4	189±77.0	179±73.7	0.070
Vegetables (g)	140±64.5	138±61.4	143±63.3	137±66.7	0.846
Fruits (g)	164±126	170±124	161±103	166±112	0.896
Meat and alternatives (g)	120±54.5^{a}	116±51.1^{a}	114±55.4^{ab}	102±50.9^{b}	0.007
Dairy and alternatives (g)	127±126^{a}	178±108^{b}	239±135^{c}	340±196^{d}	<0.0001
Supplemental calcium (mg)	2.2±11.9^{a}	2.3±16.3^{a}	5.5±31.2^{a}	17.9±95.1^{b}	0.007
Liquid discretionary (g)	300±236^{a}	279±206^{a}	264±187^{ab}	224±196^{b}	0.003
Solid discretionary (g)	198±110^{a}	180±95^{ab}	178±86.5^{ab}	156±72.0^{b}	<0.0001
Alcoholic beverages (g)	49.7±260^{a}	52.0±244^{a}	2.2±21.8^{b}	10.0±62.3^{b}	0.008

†ANCOVA adjusted for energy with post-hoc Bonferroni tests to locate significant differences. Significant differences indicated by different superscript letter; P value <0.01.

Table 3.4 Dietary characteristics of young adults (n=774) by quartile of usual calcium intake from the National Nutrition and Physical Activity survey 2011-12, based on two-day data and adjusted for energy.

Quartile (Calcium density mg/ 1000 KJ)	Q1 (30.0-71.3)	Q2 (71.3-92.2)	Q3 (92.2-116.9)	Q4 (116.9-277.4)	P-Value†
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Energy (kJ)	7808 ±2537[ac]	7525±2664[ac]	7028±2257[bc]	6437±2405[b]	<0.0001
Grains (g)	206±99.0[a]	202±109 [a]	185±85.6 [ac]	172±82.4[bc]	0.001
Vegetables (g)	147±65.2	156±67.4	157±66.8	159±75.8	0.298
Fruits (g)	153±142	143±114	168±117	155±116	0.272
Meat and alternatives (g)	139±64.1[a]	136±70.4[a]	123±58.5[ab]	111±55.4[b]	<0.0001
Dairy (g)	136±122[a]	184±127[b]	227±136[c]	311±188[d]	<0.0001
Supplement amount (mg)	0.7±6.1[a]	10.2±39.5 [a]	10.6±39.0 [a]	41.9±143[b]	<0.0001
Liquid discretionary (g)	300±225[a]	272±197 [ab]	251±211[ac]	212±171[bc]	<0.0001
Solid discretionary (g)	195±103[a]	177±108 [ab]	162±86.7[ac]	149±120[bc]	<0.0001
Alcoholic beverages (g)	315±581[ab]	220±440[ac]	105±226[b]	35.6±101[bc]	<0.0001

†ANCOVA adjusted for energy with post-hoc Bonferroni tests to locate significant differences. Significant differences indicated by different superscript letter; P value <0.01;

3.7.4 Timeline of calcium and food intake

Combined data of adolescents and young adults were used for these descriptive analyses, as the results were similar (Figure 3.3). Stratified results have been included as Supplementary Tables 3.2 and 3.3. It is evident that dairy and alternatives play a major role in providing calcium at breakfast and contribute lesser quantities at lunch and dinner. Grains provide calcium across the day; whereas vegetables supply calcium at lunch and dinner time. Intake of calcium from discretionary choices and meat and alternatives remains low in the mornings, with an increase at lunch and a more substantial contribution at dinner.

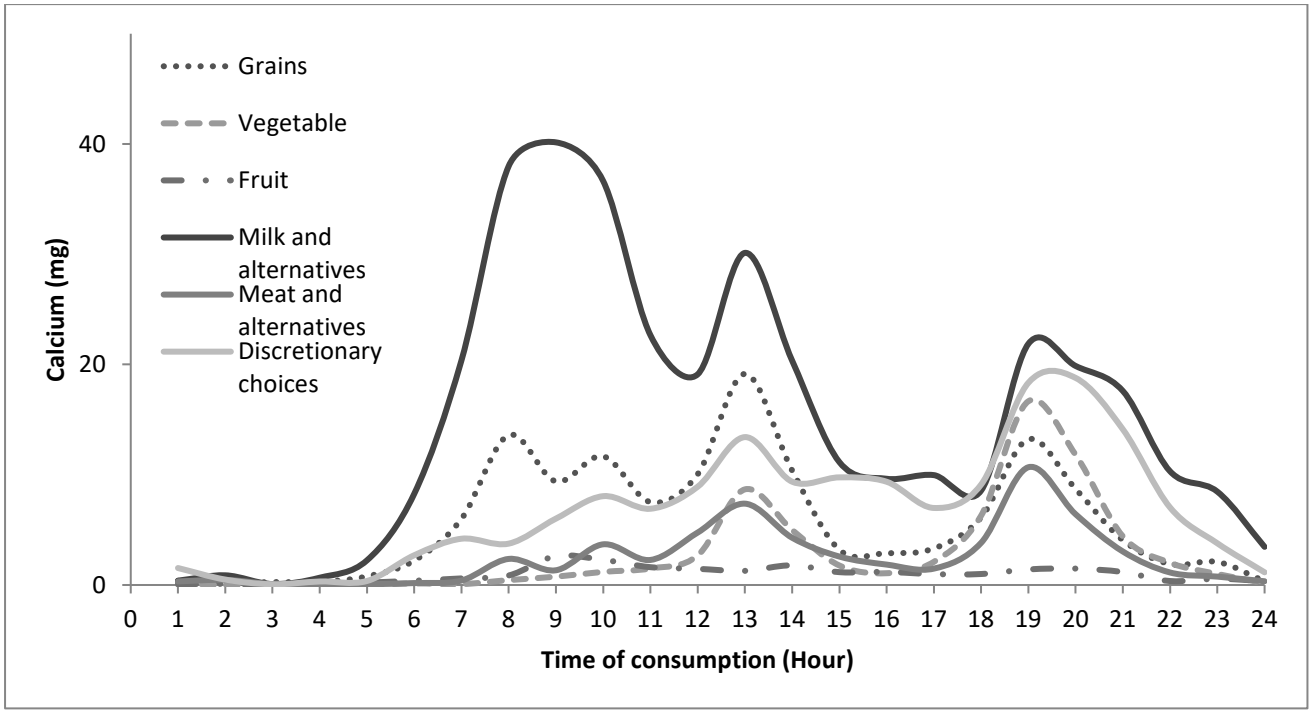

Figure 3.3 Timeline of calcium obtained from core and discretionary food groups: combined results of adolescents and young adults. Discretionary group includes solid discretionary, liquid discretionary and alcoholic beverages.

3.8 Discussion

The present analyses demonstrate that calcium intake among adolescents and young adults are inadequate compared with national recommendations. It is concerning that at best only 30% of the adolescents and young adults consumed enough calcium. Results from other national nutrition surveys around the world depict similar results demonstrating the insufficient intake in this age group [43-45]. Females are consistently at a greater risk, especially in adolescence of consuming inadequate calcium [9,44,46-48].

Despite the rise in popularity of other calcium alternatives, dairy products remain the largest source of calcium in the Australian diet. For the purpose of promoting calcium-rich foods to the population, it appears essential to include milk, yogurt, and cheese as good sources of calcium among the population. Nonetheless, alternative strategies are needed to target those who are lactose intolerant or vegan and therefore avoid dairy. A recent cross-sectional survey explored the prevalence of dairy avoidance in the Australian population, finding 11.8% reported avoidance for physical symptoms [49]. Lactose intolerance is commonly reported as a reason for low intake in African, His-panics, North East Asia, and certain indigenous communities [50]. Alternative calcium beverages contributed to <1% of the calcium intake. Many of the popular dairy alternatives (i.e., oat, almond, and coconut milk) are not fortified with calcium in Australia [51,52]. Cow's milk and plant-based drinks are nutrition-ally different and further studies are warranted to establish benefits of the latter [12]. The latter choices may be particularly relevant for those who are vegan or lactose intolerant. Supplement use was associated with a higher calcium intake but use of calcium supplements was relatively uncommon. The proportion of people consuming supplements containing any amount of calcium was <12% in our sample population of Australian adolescents and young adults. The findings can be compared with a Japanese study where only 2% of the population consumed supplements [48].

A higher intake of calcium was associated with lower intakes of all discretionary choices and consumption of calcium-rich foods could be a marker for healthier eating habits. This is in line with studies on Dutch adolescents (14-18 years) and Australian children (8-10 years) suggesting dairy foods are indicative of healthier diets [45,53]. Calcium intake declined with higher intakes of discretionary foods, beverages, and alcohol. However, no differences in fruit and vegetable intake were detected with higher calcium intakes in the present study. Others have reported a lower intake of alcohol is associated with higher calcium intakes in adolescents in the Netherlands and Brazil [44,45]. Discretionary foods are suggested to be major contributors to excessive energy consumption and weight gain. Preliminary research in this field has shown that dairy foods may assist with weight control or weight management [54-56].

Although discretionary choices are discouraged, it was found that discretionary sources contributed to higher amounts of calcium at dinner time. This may be opportunistic from fast foods, such as pizza rich in cheese. To limit intake of discretionary choices, future interventions may promote the substitution of a discretionary snack with dairy, nuts, or vegetables. The latter choices may be particularly relevant for those who are vegan or lactose intolerant. Lactose intolerance is commonly reported as a reason for low intake in African, Hispanics, North East Asia, and certain indigenous communities [50]. A recent cross-sectional survey explored the prevalence of dairy avoidance in the Australian population, finding 11.8% reported avoidance for physical symptoms [49].

Australian women are at a greater risk for low calcium intake than to men. Qualitative studies suggest this may be due to the differing attitudes women hold related to adverse health effects [57]. Perhaps, the most common deterrent reported in the literature is the perceived high fat content of dairy [58, 59] which is thought to start in adolescence among females [60]. Factors linked to lower intake in women of all ages have included fear of weight gain or elevation of

cholesterol, real or perceived intolerance, and gastrointestinal issues (i.e., gas, bloating, and diarrhea) [61-67].

Other demographic characteristics of low calcium consumers were smoking and poor education, as has previously been reported in Brazil [44] and the Netherlands [45]. Although there were no differences in calcium intake due to SEIFA or geo-graphic location in the present study, researchers in Korea and Brazil reported higher intakes in major cities compared with other geographic areas [43, 44] that may be related to income [68].

The strengths of the present study were using a national sample to conduct the analyses and using 2 d of 24-h recalls, applied with the MSM method, to estimate usual intake distributions [69, 70]. Misreporting is a limitation but it was found that calcium intake was not significantly associated with misreporting. Therefore, all data were included and allowed for observation of patterns in the entire study population. Furthermore, the present analyses disaggregated dishes that better captures all food sources.

Conclusions

Calcium intake remains below recommendations. From the present analyses, it is apparent that most of the calcium intake was obtained from dairy foods. A higher intake of calcium was associated with a healthier diet pattern. Conversely, lower calcium intakes were found in those consuming larger quantities of discretionary foods. Targeted interventions are needed for adolescents and young adults to increase their intake of calcium

3.9 References

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3.10 Conclusion to chapter

The findings revealed that females have a much lower intake and the contribution to calcium intake was primarily limited to dairy foods consumed at breakfast. As this is a crucial period for development of peak bone mass, interventions are needed to improve intakes. Future interventions should aim to promote consumption of calcium intake throughout the day. Encouraging intake at other main meals and snack times will be a key strategy for inclusion in the intervention. The next chapter will assess the efficacy of past interventions aimed to improve calcium or dairy intake in young adults.

Appendix 3

Appendix 3.1

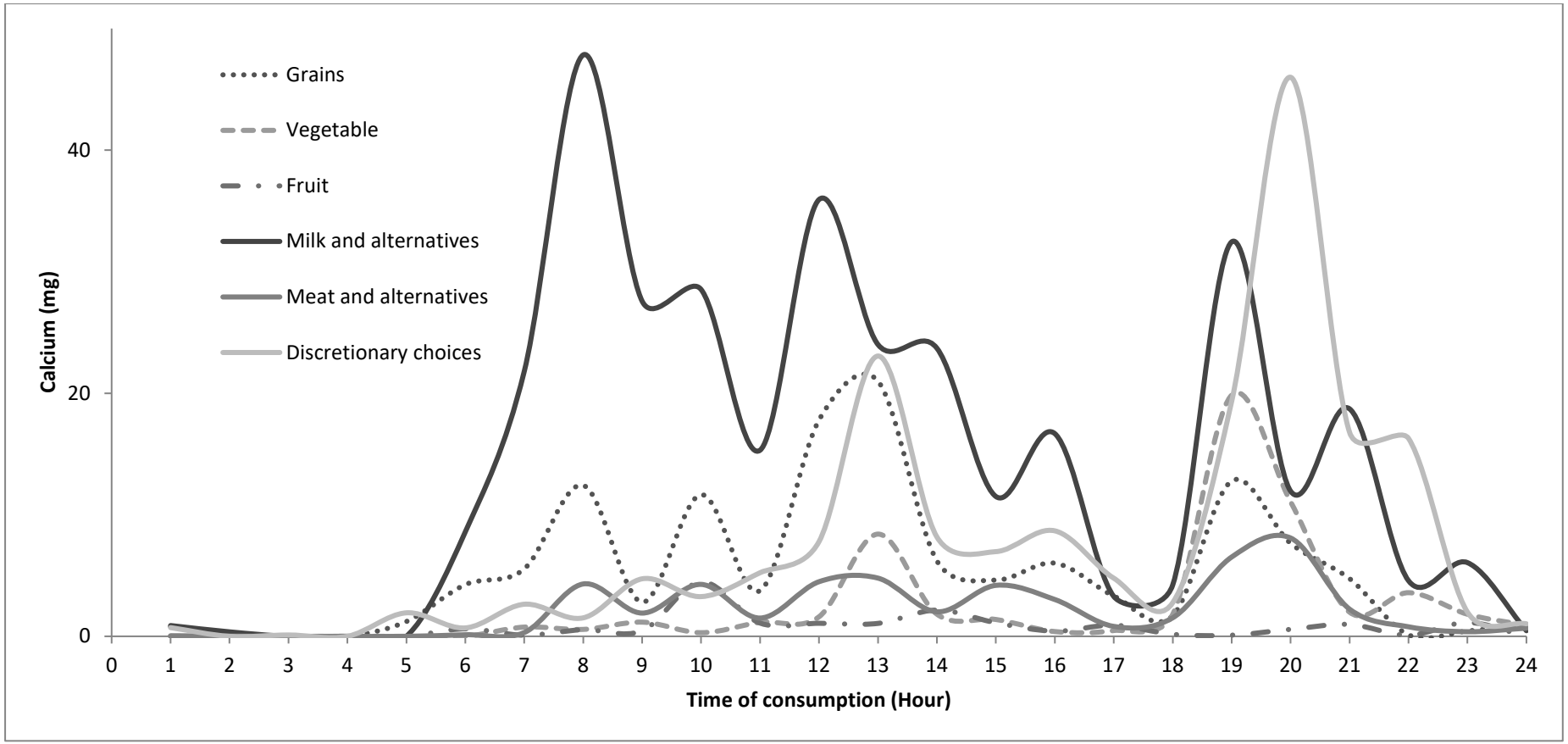
Calcium density (mg/ 1000 KJ) for subpopulations of adolescents and young adults from the National Nutrition and Physical Activity survey 2011-12, based on two-day data and adjusted for energy.

(See next page)

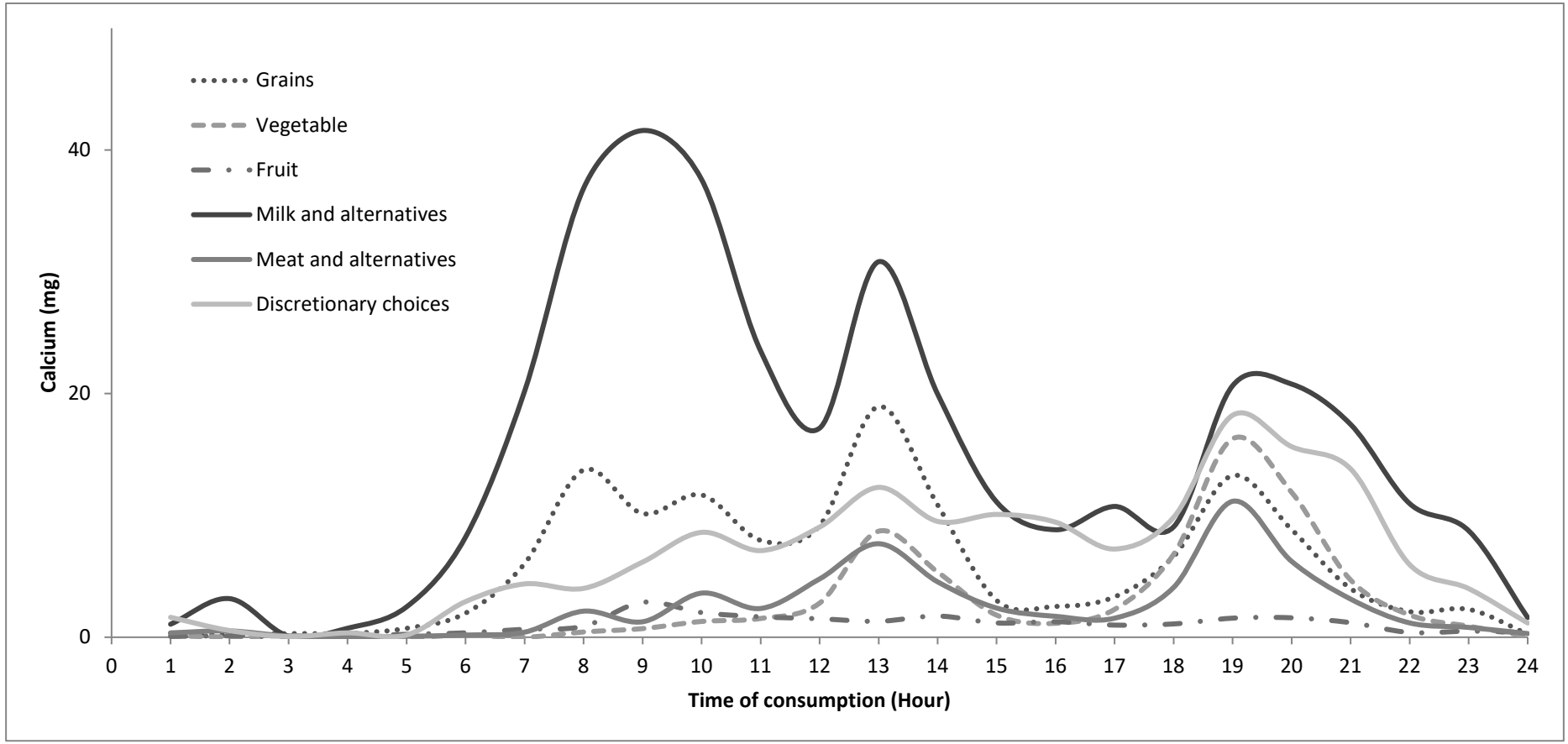
		Adolescents			Young adults		
Demographics		**n**	**Mean calcium†**	**SD**	**n**	**Mean calcium†**	**SD**
Weight category	Underweight	35	621.9	153.8	34	660.0	162.5
	Normal range	439	670.8	43.5	393	682.2	47.9
	Overweight	122	662.8	82.5	175	685.5	71.6
	Obese	48	712.9	131.4	110	689.9	91.0
	P-Value		0.351			0.936	
Country of birth	Australia	687	671.4	34.0	618	689.2	38.6
	Main English-Speaking countries‡	39	648.6	142.8	46	666.1	141.6
	Other	44	571.0	134.5	110	628.1	91.7
	P-Value		0.016			0.052	
Remoteness	Major cities	461	656.3	41.7	544	679.1	41.3
	Inner regional	160	674.7	70.9	143	668.9	80.6
	Other	149	679.3	73.5	87	696.4	100.3
	P-Value		0.463			0.712	
SEIFA	Quintile 1 - Lowest 20%	115	670.4	83.5	157	641.3	76.8
	Quintile 2	147	636.6	74.0	146	685.8	79.6
	Quintile 3	161	685.4	70.7	146	672.3	79.7
	Quintile 4	144	674.4	74.8	125	709.4	86.1
	Quintile 5 - Highest 20%	203	657.9	62.9	200	690.2	68.0
	P-Value		0.398			0.180	
Highest year of school completed	Not applicable	140	683.0	75.8			
	Year 12 or equivalent	96	677.7	91.7	567	688.9	40.2
	Year 11 or equivalent	171	650.5	68.6	92	618.9	99.8
	Year 10 or equivalent	194	666.6	64.5	95	692.5	98.3
	Year 9 or equivalent	143	648.2	75.1	15	687.8	247.1
	Year 8 or below	26	683.7	176.7	5	402.4	428.0
	P-Value		0.729			**0.010**	
Misreporting	Under-reporters	129	683.3	90.8	143	690.6	89.9
	Plausible reporters	490	669.0	41.9	550	681.0	41.5
	Over-reporters	19	602.0	226.0	20	707.2	234.5
	P-Value		0.465			0.833	
Whether currently smokes	Yes	43	612.7	136.5	168	599.3	73.2
	No	587	663.9	36.9	606	701.3	38.5
	Not applicable	140	683.0	75.7			
	P-Value		0.208			**0.000**	

†Mean calcium density in mg/ 1000 kJ SEIFA. Socio-economic indexes for areas developed by ABS that ranks Australia based on socio-economic disadvantage; ‡ main English-speaking countries include Canada, Ireland, New Zealand, South Africa, United Kingdom and the USA. P value <0.01

Appendix 3.2 Timeline of calcium obtained from core and discretionary food sources for adolescents



Appendix 3.3 Timeline of calcium obtained from core and discretionary food sources for young adults



Appendix 3.4

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Applied nutritional investigation

Low calcium intakes among Australian adolescents and young adults are associated with higher consumption of discretionary foods and beverages

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ABSTRACT

Objectives: Calcium is an essential nutrient required for peak bone mass growth during adolescence and into young adulthood. The aim of this study was to examine the calcium intake of Australian adolescents and young adults from both food sources and supplements; and the relationship between calcium intake and intake of food groups.

Methods: Dietary data from 770 adolescents (14–18 y of age) and 774 young adults (19–25 y of age) from the 2011 to 12 National Nutrition and Physical Activity Survey were used. Analysis of covariances were conducted to identify associations between calcium intake and consumption of food groups.

Results: For adolescents, 83% of males and 95% of females did not meet the Estimated Average Requirement (EAR); whereas for young adults, 69% of males and 83% of females failed to meet the EAR. Food sources contributing to calcium intake were similar across age groups and sex. The largest contributors included regular milk (15–24%), cheese (10–12%), refined low-fiber bread (10%), and low-fat milk (7–9%). For both age groups, the lowest consumers of calcium were the poorest consumers of dairy products and the highest consumers of discretionary food choices and alcoholic beverages. A higher consumption of calcium was associated with a higher intake of dairy products and lower intakes of meat and alternatives and all discretionary choices.

Conclusions: Calcium intake among Australian adolescents and young adults remains below recommendations, particularly in females. A higher intake of calcium was associated with a better dietary pattern. Further investment in interventions is indicated.

Introduction

The period between adolescence and young adulthood is one of nutritional vulnerability, including high requirements for calcium. Calcium assists in the growth of peak bone mass, 90% of which is achieved from late adolescence to the age of 20 y [1]. Adolescence is a critical time to address food intake as children start gaining independence from their parents, which can result in an increased intake of meals prepared outside the home and a lower consumption of foods from the recommended food groups [2]. The latest Australian Health Survey revealed that only 1 in 10 Australian adults are consuming the recommended amounts from the dairy and alternatives food group, which includes milk, yogurt, cheese, and alternative sources of calcium [3]. Although calcium-rich foods and beverages are commonly consumed by children in Australia [4], statistics suggest that the intake of the milk food group decreases during adolescence [5,6].

Dairy products provide the largest source of dietary calcium in Australia as well as in many other countries such as the United States [7], the United Kingdom [8], and most of northern Europe [9]; and are not easily replaced with other foods in the diet to meet nutrient requirements, as shown by nutrient modeling [10] and nutrient profiling [11]. Overall, the available evidence suggests that milk and other dairy products are important contributors to nutrient intake, diet quality, and bone health; and may provide protection against prevalent chronic diseases [12,13]

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such as ischemic heart disease, stroke, hypertension, type 2 diabetes, obesity, and metabolic syndrome [14–23], as well as reduced risk for colorectal cancer [24–26].

Females are considered to be an at-risk group for insufficient calcium intake [27]. This is concerning as low bone density is a problem, especially among postmenopausal women [28]. Previous interventions in promoting dairy products and calcium have not been very successful in adolescents and young adults [29,30]. To support this age group, it is necessary to delve into the food habits of youth and young adults, and to identify the main contributors to calcium intake and sociodemographic groups who may be at high risk. Although the Australian Bureau of Statistics (ABS) has conducted analyses of the most recent national survey, the analyses did not disaggregate the mixed dishes into their component ingredients, nor study relationships with food group intakes. The aim of the present study was to conduct secondary analyses of the National Nutrition and Physical Activity Survey (NNPAS) and to examine the relationship between calcium intake and consumption of the recommended and discretionary food groups.

Methods

Data collection

The data analyzed in the present study were collected as part of the 2011–2012 NNPAS conducted by the ABS from May 2011 to June 2012 throughout Australia using nationally representative subsamples. Ethics approval for the survey was obtained from the Australian Department of Health and Ageing Departmental Ethics Committee in 2011. A detailed description of the survey methods and data collection has been reported elsewhere [31]. In brief, 12 154 respondents were interviewed face-to-face to collect demographic, anthropometric, and dietary data. Food and beverage consumption data were obtained by trained staff using a multiple-pass 24-h computer-assisted person interview. A second-day recall was conducted by telephone in a subsample of 64% of respondents. Adult respondents were interviewed in person, and children between the ages of 15 and 17 y were interviewed if permission was granted by parent or parental proxy. For 14 y olds, the parents were proxies as reported previously [32]. The estimation of food, beverage, and nutrients were obtained from the AUSNUT 2011–2013 food composition database, which was developed specifically for the NNPAS [33]. The present study focused on the calcium intake of adolescents ages 14 to 18 y and young adults ages 19 to 25 y.

Assessment of calcium intake

All intake data from mixed dishes were disaggregated by estimating the individual food components from a mixed dish using the AUSNUT 2011–2013 recipe file [33,34]. Previous analyses had not conducted this analysis. Foods were classified according to the four-digit food code from the Australian Dietary Guidelines database compiled by Food Standards Australia New Zealand [35]. Calcium intake was obtained from all foods, beverages, and supplements using AUSNUT 2011–2013. To establish the proportion of the population taking supplements, respondents were coded as "consuming" and "non-consuming" based on self-report. Throughout this study, "calcium supplement" referred to any supplement containing calcium, including multivitamins that contain small amounts of calcium.

The usual intakes of respondents' total energy and calcium intake were estimated from two 24-h recalls using the Multiple Source Method (MSM) where a Box-Cox transformation was applied to normalize the data before estimating the usual intake [36]. Women who were pregnant or breastfeeding were excluded due to their different nutrient requirements.

Comparison to national recommendations

The usual calcium intakes were compared with the Estimated Average Requirement (EAR) of calcium for adolescents ages 14 to 18 y (840 mg) and young adults ages 19 to 30 y (1050 mg) [37].

Food groups

The food categories used in this analysis were the recommended food groups that included grain (cereal) foods; vegetables and legumes/beans; fruit; lean meats and poultry, fish, eggs, tofu, nuts and seeds and legumes/ beans; and milk, yogurt, cheese and/or alternatives [38,39]. For simplicity purposes, the categories from the five food groups are referred to as grains, vegetables, fruit, meat and alternatives, and dairy and alternatives throughout. Discretionary foods were categorized as solid choices (cakes, biscuits, fast foods), liquid choices (soft drink, sugar-sweetened beverages), and alcoholic beverages [31,40].

Demographic covariates

Demographic factors collected included weight status (underweight, normal range, overweight, or obese), country of birth (born in Australia, English-speaking countries, or other), geographic location (major cities, inner regional, or other) and highest year of school completed (year 12 or equivalent, year 11 or equivalent, year 10 or equivalent, year 9 or equivalent, year 8 or below). Socioeconomic quintiles were derived from the Socio-Economic Index of Disadvantage for Areas (SEIFA), where the most disadvantaged areas were classed as the first SEIFA quintile [40]. Other self-reported variables included current smoking status (yes/no), physical activity recommendations met (yes/no), and use of calcium supplements (yes/no). The methodology used to collect this data has been described elsewhere [31].

Timeline of calcium and food intake

The mean calcium intakes for each hour of the day were calculated and mean contribution from each of the food groups was determined. These were used for a graphical representation of the data.

Statistical analyses

Descriptive statistics were tabulated to display sample characteristics. Usual calcium intake (food sources and supplements) using two dietary recalls were reported in this study to estimate proportions meeting EAR. As dietary misreporting has been identified in the 2011–2012 NNPAS [41], a categorical variable was created to classify underreporters, plausible, and overreporters. Energy reporting status was categorized based on the Goldberg cutoffs (energy intake to basal metabolic rate of ≤0.87 for underreporters, 0.88–2.66 for plausible reporters, and ≥2.67 for overreporters) [42].

The usual calcium intake of respondents was categorized into quartiles to assess differences in food group intakes. Calcium intake was calculated as calcium density in mg per 1000 kJ to adjust for energy intake. For continuous variables, a one-way analysis of covariance (ANCOVA) was used for determination of linear trends. A post-hoc test (Bonferroni) was applied to locate the group differences. All statistical analyses were performed using SPSS for Windows 22 software (IBM, Armonk, NY USA). $P < 0.01$ was considered statistically significant for all tests due to the large number of comparisons.

Results

Comparison to national recommendations

The sample included 770 adolescents and 774 young adults distributed across sex and SEIFA. Approximately 18% of the respondents were classed as underreporters and 1% to 4% were classed as overreporters for both age groups. The demographic characteristics of the sample stratified by age and sex are shown in Table 1. For adolescents, 83.1% of boys and 94.8% of the girls had calcium intakes below the EAR. For young adults, 68.9% of males and 82.9% of the females were consuming below the EAR.

Calcium intake and food sources

Table 2 shows nutrient and food group data stratified by age and sex for the five food groups and discretionary choices. The mean (SD) usual calcium intakes for males were 738 ± 303 mg and 737 ± 342 mg for adolescents and young adults, respectively. For females, the usual intakes were 583 ± 258 mg and 621 ± 176 mg for adolescents and young adults, respectively. The proportion of the population using calcium supplements was 7.1% and 11.8% for adolescents and young adults, respectively; and accounted for <1% of the total calcium intake (Table 2). The main food sources of calcium were ranked as shown in Figures 1 and

Table 1
Sample demographic characteristics from the National Nutrition and Physical Activity Survey 2011–2012; proportions (%) by age and sex

		Both age groups		Adolescents		Young adults	
		% Males (n = 786)	% Females (n = 758)	% Males (n = 403)	% Females (n = 367)	% Males (n = 383)	% Females (n = 391)
Weight status	Underweight	4.7	5.5	5.2	5.7	4.2	5.4
	Normal range	60	62.8	68.7	67.6	51.5	58.6
	Overweight	25.3	18.3	20.1	17.6	30.3	18.9
	Obese	10.1	13.4	6	9.1	14	16.9
Country of birth	Australia	82.8	86.3	88.8	89.6	76.5	83.1
	Main English-speaking countries*	5.1	5.9	4.5	5.7	5.7	6.1
	Other	12.1	7.8	6.7	4.6	17.8	10.7
Remoteness	Major cities	65.9	64.2	59.3	60.5	72.8	67.8
	Inner regional	18.6	20.7	21.3	20.2	15.7	21.2
	Other	15.5	15	19.4	19.3	11.5	11
SEIFA†	Lowest 20%	17	18.2	17.1	12.5	17	23.5
	Second quintile	18.8	19.1	17.6	20.7	20.1	17.6
	Third quintile	19.6	20.2	19.4	22.6	19.8	17.9
	Fourth quintile	18.2	16.6	18.1	19.3	18.3	14.1
	Fifth quintile	26.3	25.9	27.8	24.8	24.8	26.9
Currently smokes	Yes	13.7	13.6	6.90	4.1	20.9	22.5
Physical Activity	Met recommendations	Not measured for adolescents		Not measured		57.7	50.9
Misreporting‡	Underreporters	15.3	20.1	15.6	18	14.9	22
	Plausible reporters	70.2	64.4	66.5	60.5	74.2	68
	Overreporters	3.7	1.3	3.2	1.6	4.2	1
	Could not be classified	10.8	14.2	14.6	19.9	6.8	90
Calcium intake	Inadequate intake	76.0	88.7	83.1	94.8	68.9	82.9

BMR, basal metabolic rate; SEIFA, Socio-Economic Index of Disadvantage for Areas.
* Main English-speaking countries include Canada, Ireland, New Zealand, South Africa, the United Kingdom, and the United States.
† Socioeconomic indexes for areas developed by Australian Bureau of Statistics, which ranks Australia based on socioeconomic disadvantage.
‡ Misreporting. Underreporters (energy intake vs BMR <0.87), plausible reporter (energy intake vs BMR ≤0.87 to ≥2.67), overreporters (energy intake vs BMR ≥2.68) and could not be classified if insufficient data was provided by respondents.

2. For both population groups, the top contributors included regular milk, cheese, bread, and low-fat milk. Fewer young adults drank milk (contributing 16–18% of total calcium) compared with adolescents (contributing 20–24%). Calcium alternative beverages were consumed by a larger proportion of young adult females compared with the other groups (Fig. 2). A minor contribution to calcium intake was made by fish and seafood, dairy snacks, legumes, and tofu.

Dietary and demographic characteristics

Tables 3 and 4 present the dietary characteristics by quartiles of usual calcium intake (energy adjusted) for adolescents and young adults, respectively. A higher calcium intake was associated with a lower intake of meat and alternatives, solid and liquid discretionary choices, and alcoholic beverages but a higher intake of dairy products and supplements. Fruits and vegetable intake did not differ between quartiles. A higher intake of calcium was associated with lower intake of energy and grains for young adults only.

No differences in calcium intake according to plausible or misreporting of dietary intake were found (Ssupplementary Table 1). Some differences in calcium intake were found for those who were born in Australia (higher intake) compared with those born in other countries ($P = 0.016$ for adolescents; $P = 0.052$ for young adults). Attainment of education was significantly associated with calcium intake in young adults ($P = 0.01$) but not for adolescents. For young adults, smoking was significantly associated with lower calcium intake.

Timeline of calcium and food intake

Combined data of adolescents and young adults were used for these descriptive analyses, as the results were similar (Fig. 3). Stratified results have been included as Supplementary Tables

Table 2
Usual dietary intakes* of adolescents and young adults from the National Nutrition and Physical Activity survey 2011–2012

Mean ± SD	All ages		Adolescents		Young adults	
	Males (n = 786)	Females (n = 758)	Male (n = 403)	Females (n = 367)	Males (n = 383)	Females (n = 391)
Energy intake (kJ)	8102 ± 2465	6103 ± 1744	7892 ± 2195	6104 ± 1766	8322 ± 2705	6103 ± 1725
Calcium intake (mg)	738 ± 323	603 ± 259	739 ± 304	583 ± 259	738 ± 342	622 ± 177
Calcium supplement (mg)	11.3 ± 69.3	11.6 ± 62.8	7.9 ± 63.3	5.9 ± 33.6	14.8 ± 74.9	16.9 ± 80.9
Grains (g)	214 ± 96.3	164 ± 73.1	205 ± 88.6	168 ± 71.5	224 ± 103	160 ± 74.5
Vegetables (g)	152 ± 70.2	142 ± 62.9	143 ± 65.2	136 ± 62.4	162 ± 73.9	148 ± 63
Fruit (g)	157 ± 124	163 ± 115	160 ± 115	171 ± 117	153 ± 32	156 ± 113
Dairy and alternatives (g)	239 ± 173	195 ± 147	244 ± 170	196 ± 155	234 ± 176	195 ± 138
Meat and alternatives (g)	139 ± 64.6	100 ± 44.7	127 ± 56.2	97.5 ± 45.4	151 ± 70.3	103 ± 44
Liquid discretionary (g)	308 ± 224	216 ± 1734	316 ± 227	213 ± 170	301 ± 221	218 ± 177
Solid discretionary (g)	196 ± 115	152 ± 75.6	195 ± 100	160 ± 81	197 ± 128	145 ± 69.6
Alcoholic beverages (g)	151 ± 413	45.1 ± 154	48.6 ± 242	6.4 ± 67.5	258 ± v516	81.5 ± 198

* Usual intake was determined using two 24-h dietary recalls. The food groups are in accordance with the recommended five food groups from the Australian Dietary Guidelines (full description included in Methods).

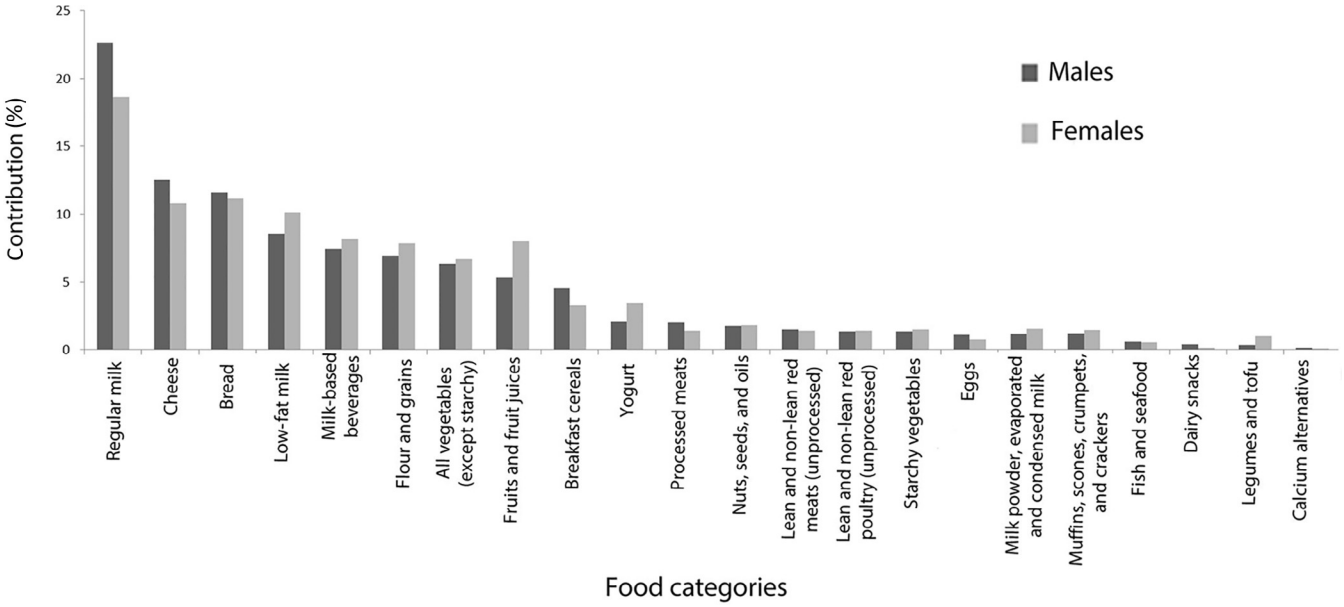

Fig. 1. Percent contribution of calcium intake among Australian adolescents ages 14 to 18 y from major food groups.

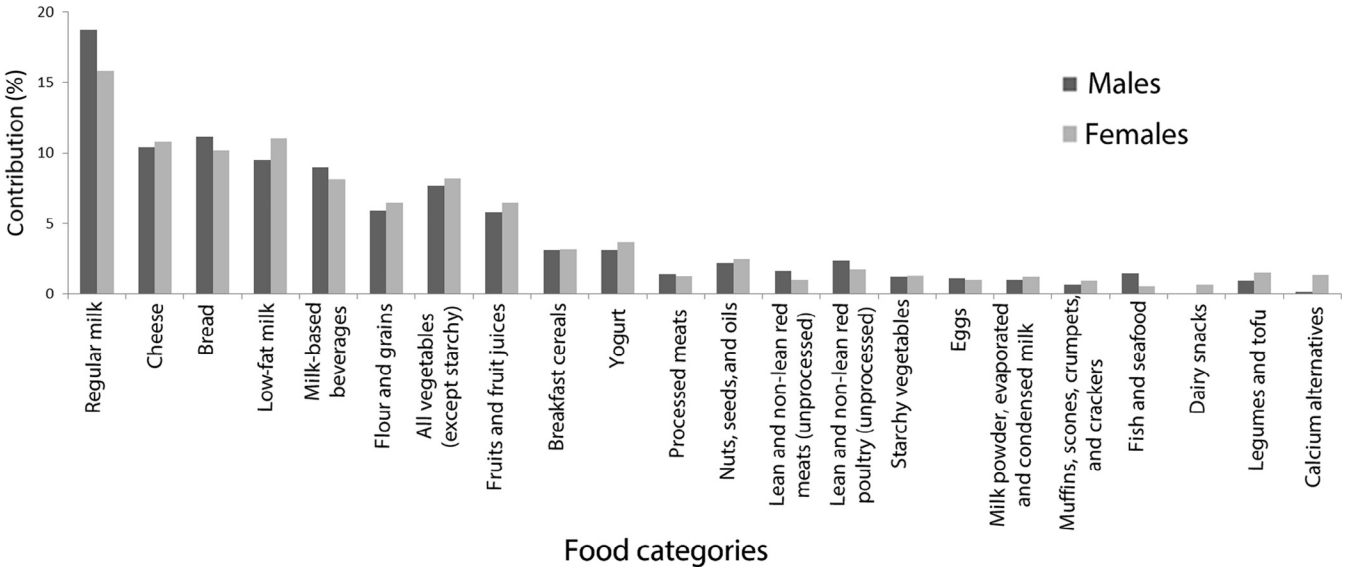

Fig. 2. Percent contribution of calcium intake among Australian young adults ages 19 to 25 y from major food groups.

2 and 3. It is evident that dairy and alternatives play a major role in providing calcium at breakfast and contribute lesser quantities at lunch and dinner. Grains provide calcium across the day; whereas vegetables supply calcium at lunch and dinner time. Intake of calcium from discretionary choices and meat and alternatives remains low in the mornings, with an increase at lunch and a more substantial contribution at dinner.

Discussion

The present analyses demonstrate that calcium intake among adolescents and young adults are inadequate compared with national recommendations. It is concerning that at best only 30% of the adolescents and young adults consumed enough calcium. Results from other national nutrition surveys around the world depict similar results demonstrating the insufficient intake in this age group [43–45]. Females are consistently at a greater risk, especially in adolescence of consuming inadequate calcium [9,44,46–48].

Despite the rise in popularity of other calcium alternatives, dairy products remain the largest source of calcium in the Australian diet. For the purpose of promoting calcium-rich foods to the population, it appears essential to include milk, yogurt, and cheese as good sources of calcium among the population. Nonetheless, alternative strategies are needed to target those who are lactose intolerant or vegan and therefore avoid dairy. A recent cross-sectional survey explored the prevalence of dairy avoidance in the Australian population, finding 11.8% reported

Table 3
Dietary characteristics of adolescents (n = 770) by quartile of usual calcium intake from the National Nutrition and Physical Activity survey 2011–2012, based on 2-d data and adjusted for energy

Quartile (calcium density mg/1000 kJ)	Q1 (32.1–71.6)	Q2 (71.6–91.5)	Q3 (91.5–111.6)	Q4 (111.6–241.8)	*P*-value*
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Energy (kJ)	7348 ± 2494	6856 ± 1976	7025 ± 2212	6926 ± 2025	0.127
Grains (g)	200 ± 100	183 ± 77.4	189 ± 77	179 ± 73.7	0.070
Vegetables (g)	140 ± 64.5	138 ± 61.4	143 ± 63.3	137 ± 66.7	0.846
Fruits (g)	164 ± 126	170 ± 124	161 ± 103	166 ± 112	0.896
Meat and alternatives (g)	120 ± 54.5 [a]	116 ± 51.1 [a]	114 ± 55.4 [ab]	102 ± 50.9 [b]	0.007
Dairy and alternatives (g)	127 ± 126 [a]	178 ± 108 [b]	239 ± 135 [c]	340 ± 196 [d]	<0.0001
Supplemental calcium (mg)	2.2 ± 11.9 [a]	2.3 ± 16.3 [a]	5.5 ± 31.2 [a]	17.9 ± 95.1 [b]	0.007
Liquid discretionary (g)	300 ± 236 [a]	279 ± 206 [a]	264 ± 187 [ab]	224 ± 196 [b]	0.003
Solid discretionary (g)	198 ± 110 [a]	180 ± 95 [ab]	178 ± 86.5 [ab]	156 ± 72 [b]	<0.0001
Alcoholic beverages (g)	49.7 ± 260 [a]	52 ± 244 [a]	2.2 ± 21.8 [b]	10 ± 62.3 [b]	0.008

Significant differences between quartiles are indicated by a different superscript letter.
* Analysis of covariance adjusted for energy with post hoc Bonferroni tests to locate significant differences. Significant differences indicated by different superscript letter; $P < 0.01$.

Table 4
Dietary characteristics of young adults (n = 774) by quartile of usual calcium intake from the National Nutrition and Physical Activity survey 2011–2012, based on 2-d data and adjusted for energy

Quartile (calcium density mg/1000 kJ)	Q1 (30–71.3)	Q2 (71.3–92.2)	Q3 (92.2–116.9)	Q4 (116.9–277.4)	*P*-value*
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Energy (kJ)	7808 ± 2537 [ac]	7525 ± 2664 [ac]	7028 ± 2257 [bc]	6437 ± 2405 [b]	<0.0001
Grains (g)	206 ± 99 [a]	202 ± ± 109 [a]	185 ± 85.6 [ac]	172 ± 82.4 [bc]	0.001
Vegetables (g)	147 ± 65.2	156 ± 67.4	157 ± 66.8	159 ± 75.8	0.298
Fruits (g)	153 ± 142	143 ± 114	168 ± 117	155 ± 116	0.272
Meat and alternatives (g)	139 ± 64.1 [a]	136 ± 70.4 [a]	123 ± 58.5 [ab]	111 ± 55.4 [b]	<0.0001
Dairy and alternatives (g)	136 ± 122 [a]	184 ± 127 [b]	227 ± 136 [c]	311 ± 188 [d]	<0.0001
Supplemental calcium (mg)	0.7 ± 6.1 [a]	10.2 ± 39.5 [a]	10.6 ± 39 [a]	41.9 ± 143 [b]	<0.0001
Liquid discretionary (g)	300 ± 225 [a]	272 ± 197 [ab]	251 ± 211 [ac]	212 ± 171 [bc]	<0.0001
Solid discretionary (g)	195 ± 103 [a]	177 ± 108 [ab]	162 ± 86.7 [ac]	149 ± 120 [bc]	<0.0001
Alcoholic beverages (g)	315 ± 581 [ab]	220 ± 440 [ac]	105 ± 226 [b]	35.6 ± 101 [bc]	<0.0001

Significant differences between quartiles are indicated by a different superscript letter.
* Analysis of covariance adjusted for energy with post hoc Bonferroni tests to locate significant differences. Significant differences indicated by different superscript letter; $P < 0.01$.

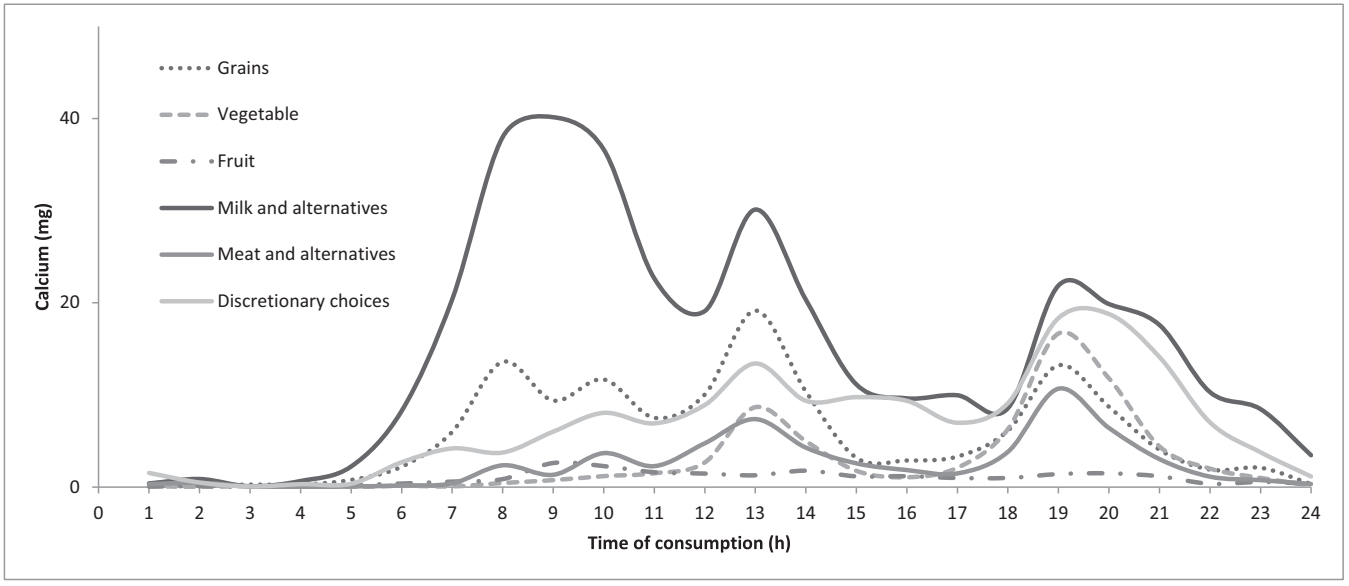

Fig. 3. Timeline of calcium obtained from core and discretionary food groups: Combined results of adolescents and young adults. Discretionary group includes solid discretionary, liquid discretionary, and alcoholic beverages.

avoidance for physical symptoms [49]. Lactose intolerance is commonly reported as a reason for low intake in African, Hispanics, North East Asia, and certain indigenous communities [50]. Alternative calcium beverages contributed to <1% of the calcium intake. Many of the popular dairy alternatives (i.e., oat, almond, and coconut milk) are not fortified with calcium in Australia [51,52]. Cow's milk and plant-based drinks are nutritionally different and further studies are warranted to establish benefits of the latter [12]. The latter choices may be particularly relevant for those who are vegan or lactose intolerant.

Supplement use was associated with a higher calcium intake but use of calcium supplements was relatively uncommon. The proportion of people consuming supplements containing any amount of calcium was <12% in our sample population of Australian adolescents and young adults. The findings can be compared with a Japanese study where only 2% of the population consumed supplements [48].

A higher intake of calcium was associated with lower intakes of all discretionary choices and consumption of calcium-rich foods could be a marker for healthier eating habits. This is in line with studies on Dutch adolescents (14–18 y) and Australian children (8–10 y) suggesting dairy foods are indicative of healthier diets [45,53]. Calcium intake declined with higher intakes of discretionary foods, beverages, and alcohol. However, no differences in fruit and vegetable intake were detected with higher calcium intakes in the present study. Others have reported a lower intake of alcohol is associated with higher calcium intakes in adolescents in the Netherlands and Brazil [44,45]. Discretionary foods are suggested to be major contributors to excessive energy consumption and weight gain. Preliminary research in this field has shown that dairy foods may assist with weight control or weight management [54–56].

Although discretionary choices are discouraged, it was found that discretionary sources contributed to higher amounts of calcium at dinner time. This may be opportunistic from fast foods, such as pizza rich in cheese. To limit intake of discretionary choices, future interventions may promote the substitution of a discretionary snack with dairy, nuts, or vegetables. The latter choices may be particularly relevant for those who are vegan or lactose intolerant. Lactose intolerance is commonly reported as a reason for low intake in African, Hispanics, North East Asia, and certain indigenous communities [50]. A recent cross-sectional survey explored the prevalence of dairy avoidance in the Australian population, finding 11.8% reported avoidance for physical symptoms [49].

Australian women are at a greater risk for low calcium intake than to men. Qualitative studies suggest this may be due to the differing attitudes women hold related to adverse health effects [57]. Perhaps, the most common deterrent reported in the literature is the perceived high fat content of dairy [58,59] which is thought to start in adolescence among females [60]. Factors linked to lower intake in women of all ages have included fear of weight gain or elevation of cholesterol, real or perceived intolerance, and gastrointestinal issues (i.e., gas, bloating, and diarrhea) [61–67].

Other demographic characteristics of low calcium consumers were smoking and poor education, as has previously been reported in Brazil [44] and the Netherlands [45]. Although there were no differences in calcium intake due to SEIFA or geographic location in the present study, researchers in Korea and Brazil reported higher intakes in major cities compared with other geographic areas [43,44] that may be related to income [68].

The strengths of the present study were using a national sample to conduct the analyses and using 2 d of 24-h recalls, applied with the MSM method, to estimate usual intake distributions [69,70]. Misreporting is a limitation but it was found that calcium intake was not significantly associated with misreporting. Therefore, all data were included and allowed for observation of patterns in the entire study population. Furthermore, the present analyses disaggregated dishes that better captures all food sources.

Conclusions

Calcium intake remains below recommendations. From the present analyses, it is apparent that most of the calcium intake was obtained from dairy foods. A higher intake of calcium was associated with a healthier diet pattern. Conversely, lower calcium intakes were found in those consuming larger quantities of discretionary foods. Targeted interventions are needed for adolescents and young adults to increase their intake of calcium.

Acknowledgments

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Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.nut.2018.04.005.

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Chapter Four

Assessing the efficacy and external validity of interventions promoting calcium or dairy intake in young adults: a systematic review with meta-analysis

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4.1 Publication details

This chapter is a reformatted version containing identical text of the manuscript entitled 'Assessing the efficacy and external validity of interventions promoting calcium or dairy intake in young adults: a systematic review with meta-analysis' published in *Critical Reviews in Food Science and Nutrition*, 2018, Volume 58, Issue 15, Pages 2600 to 2616. DOI: 10.1080/10408398.2017.1336508 (see *Appendix 4.6*). This journal is one of the highest rated journals in the field of dietetics with an impact factor (2017) of 6.202.

4.2 Author contribution

I Anika Rouf (the candidate) was the primary researcher involved in developing the research question and drafting the first version of the manuscript. The secondary author Ms Amanda Grech assisted with screening of articles and data extraction. The school librarian Monica Cooper provided assistance with setting up the database for search strategy. The senior author MA-F provided comment throughout the review process and critical comment for the final manuscript.

4.3 Introduction to the chapter

It is evident from Chapter Three that calcium intakes are low in Australian adolescents and young adults. In order to develop an effective intervention, it is important to research the success of previous interventions that have been conducted. This chapter reports a qualitative and quantitative synthesis of published studies that focused on improving calcium or dairy intake of young adults. The initial systematic review included adolescents (14-17 years) and young adults (18-35 years). However, the editors of the journal (*Critical Reviews in Food Science and Nutrition*) requested us to exclude adolescents as a similar review had been completed for this group. A meta-analysis was performed to establish an effect size. The evidence was graded using the Cochrane Collaborations Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework to determine the quality of the body of work.

4.4 Abstract

Calcium and dairy products have a role in the prevention of chronic diseases and attainment of peak bone mass, during adolescence to young adulthood. However, intakes are often suboptimal and interventions to improve consumption of food sources are needed. This systematic review aimed to investigate the efficacy and external validity of interventions promoting calcium or dairy foods among young adults. Eight databases were searched from inception to identify relevant studies. Inclusion criteria included those aged 18 to 35 years in an intervention promoting calcium or dairy food intake. The mean age of the participants was 19.9 ± 1.4 years. Of the 16 studies that met the selection criteria, five studies were included in the meta-analyses for calcium (pooled effect size 0.35, 95% CI 0.04 to 0.67) and three studies for dairy (pooled effect size 0.31, 95% CI 0.11 to 0.50). The quality of the body of evidence

was determined using the GRADE system, and was of overall low quality with high risk of bias. Our review suggests young adults respond favourably to interventions but the effect size is small.

4.5 Introduction

Dairy foods provide the major source of calcium in the Australian diet along with other essential micronutrients including protein, vitamins (A, B12, and riboflavin) and minerals (P, Mg, K, and Zn) (Weaver,2009; Yantcheva et al.,2016). Calcium and dairy products have a role in the maintenance of good health and prevention of chronic disease (Larson et al.,2009), and are recommended in the dietary guidelines in many countries (Ebeling Peter et al., 2013; National Health and Medical Research Council,2013; Food and Agriculture Organisation of the United Nations,2016; U.S. Department of Health and Human Services and U.S. Department of Agriculture,2015).

There is a growing body of evidence connecting dairy foods consumption with improved health outcomes, through improved weight control (Doidge and Segal,2012; Dougkas et al.,2011). Two or more servings of dairy foods consumption per day was associated with reduced risk of ischemic heart dis-ease and myocardial infarction (Elwood et al.,2008; Elwood et al.,2004; National Health and Medical Research Council,2011), and associated with reduced risk of stroke (Alvarez-Leon et al.,2006; de Goede et al.,2016; National Health and Medical Research Council,2011). Three servings of low-fat dairy products are associated with reduced risk of hypertension (McGrane et al.,2011; National Health and Medical Research Council,2011). Increased dairy foods consumption may also be inversely associated with insulin resistance syndrome, also known as metabolic syndrome or syndrome X

(Martins et al.,2015; Pereira et al.,2002), and reducing type two diabetes (Elwood et al.,2008; National Health and Medical Research Council,2011; Pereira et al.,2002; Pittas et al.,2007).

Despite the established benefits of dairy products and alter-natives for chronic disease prevention, it still remains a reluctant choice among adults. In the latest survey results in Australia, 90% of the Australian population (aged two years and over) do not consume enough dairy foods (Australian Bureau of Statistics,2016). They are commonly consumed by children (Australian Bureau of Statistics,2012), but statistics suggest that the intake of dairy products and alternatives decrease during adolescence (Baird et al.,2012; Parker et al.,2012). From the latest Australian Nutrition and Physical Activity Survey (NNPAS) 2011–12, almost 45% of males and 70% off males aged 19 to 30 years have inadequate calcium intakes (Australian Bureau of Statistics,2015). This raises some concern as sufficient intake of calcium is necessary, particularly during adolescence and young adulthood, to maximize peak bone mass (Matkovic,1992), and increasing dairy intake may displace the consumption of energy-dense, high-fat foods and soft drinks (Rampersaud et al. 2003; Rangan et al.,2012; Vartanian et al.,2007)

The transition to adulthood is a period often associated with developing more autonomy over dietary choices (Allman-Farinelli et al.,2016). Young adulthood is a vulnerable time, as they are entering new environments (i.e. moving out of home, starting col-lege or university) and gaining independence from their parents (Deshpande et al.,2009). These changes may lead to engagement in risky behaviors and reduced concern about their future well-being (Harhay and King,2012). Consequently, they are vulnerable to developing lifelong unhealthy behaviors (Ha et al.,2009). This is concerning, given that the habits formed can have a substantial effect in later life but also for future generations (Gore et al.,2011). Therefore, it is

important that this group be targeted separately to instil healthy behaviors (National Health and Medical Research Council,2015; Nour et al.,2016).

Previous systematic reviews have focused on interventions on dairy foods and calcium consumption in children and adolescents (Hendrie et al.,2013; Marquez et al.,2015), or in elderly adults at risk of developing osteoporosis (Kastner and Straus,2008; Little and Eccles,2010; Locketal.,2006).There has been little research on effective lifestyle programmes in the young adult age group (Hebden et al.,2012; National Health and Medical Research Council,2015). In the recent years, there has been a shift towards electronic interventions due to rising use of technology to promote better health (Kohl et al.,2013). To date, there is no published review investigating the effectiveness of calcium and dairy interventions in young adults. In order to translate interventions into the broader young adult population, it is essential to examine the external validity which is considered as important as efficacy (Steckler and McLeroy,2008). There-fore, the aim of this review was to examine the efficacy of dairy and calcium interventions targeting young adults and assess the quality of the studies and external validity components reported.

4.6 Methods

The review has been registered with Prospero (Registration number: CRD42016035908). The PRISMA guidelines were used in the synthesis of the review (Moher et al.,2009).

4.6.1 Eligibility criteria

Criteria for inclusion included young adults, defined as those aged 18 to 35 years, as this is considered the acceptable range based on the National Institute of Health cut-offs (National Institutes of Health,2010) in an intervention that promoted calcium or dairy intake, with or

without a comparison group. The outcome of measure was change in calcium or dairy intake at baseline and post-intervention. The outcome could be reported in servings or frequencies. Randomized controlled trials (RCTs), quasi-experimental design, and before and after studies with a primary or secondary aim to increase calcium or dairy intake were included. Comparison was made between baseline and follow-up, as well as between intervention and control group. Control group may be no intervention or minimal contact.

4.6.2 Information sources

A systematic search was conducted using the following academic databases: Cinahl, Embase, Global Health, Medline, Pre-Medline, PsycINFO, Scopus and The Cochrane Library. These databases were searched from inception to 22nd May 2017 to select relevant articles. A search strategy for Medline was developed first and revised appropriately for each database. A combination of subject and keyword search was used to retrieve more relevant papers. For subject searching, relevant terms were searched on all databases and subject headings were chosen (where relevant). For example, 'telemedicine' was found on Medline thesaurus Medical Subject Headings (MeSH) which encompasses the terms 'mHealth', 'eHealth', 'telehealth' and 'mobile health'. The keyword search terms for interventions were broad, including electronic ('email', 'texting', 'mobile phones', 'smartphones') and non-electronic interventions ('nutrition intervention', 'health education', 'nutrition education', 'dietary records').

No restriction limit was used on databases except for language (English) and studies involving 'humans' (where applicable). The complete search strategy in the electronic database Medline is presented in Table 4.1 (refer to supplementary tables for full search strategy). Additional studies were retrieved by hand searching the reference list of relevant studies.

Table 4.1 Electronic database search: Medline

Search ID number	Search terms	Results
1	Young Adult/	473361
2	Students/	40762
3	Youth* .tw	41829
4	(Young* adj2 (adult* or person* or people)).tw.	89813
5	College student*.tw.	12779
6	University student*.tw.	7540
7	or/1-6	2009668
8	exp Dairy Products/	79847
9	Calcium, Dietary/	12999
10	or/8-9	91783
11	Telemedicine/	13171
12	Electronic Mail/	2075
13	exp Internet/	57138
14	Mobile Applications/	819
15	exp Cell Phones/	6658
16	Telephone/	9838
17	Reminder Systems/	2550
18	Social Networking/	1337
19	Information Dissemination/	11843
20	Computer Systems/	11937
21	Ehealth*.tw.	762
22	Mhealth*.tw.	342
23	E-health*.tw.	1132
24	M-health*.tw.	108
25	Mobile health.tw.	592
26	Telehealth.tw.	1668
27	Text*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	78307
28	SMS.tw.	3117
29	Health messag*.tw.	1392
30	Social media.tw.	1784
31	Electronic health.tw.	5165
32	Telecommunication.tw.	1013
33	Computer based.tw.	10083
34	Electronic Communication.tw.	561

35	Smartphone*.tw.	1397
36	Diet/	126793
37	Mobile app*.tw.	396
38	Diet Records/	4359
39	Education, Distance/	2903
40	Food Preferences/	10770
41	Social Control, Informal/	3542
42	Social Support/	55800
43	Nutritional Sciences/	10778
44	Food Habits/	24013
45	Health Promotion/	58486
46	Education/	18872
47	Health Communication/	918
48	Health Literacy/	2445
49	Consumer Health Information/	2322
50	Health knowledge, attitudes, practice/	81149
51	Individual session*.tw.	540
52	Group session*.tw.	2242
53	Phone call*.tw.	1711
54	Dietary intervention*.tw.	4298
55	Dietary program*.tw.	144
56	Nutrition intervention*.tw.	1341
57	Nutrition program*.tw.	1636
58	Nutrition education*.tw.	2920
59	Education program*.tw.	19706
60	or/11-59	577665
61	7 and 10 and 60	1469
62	limit 63 to English language	1378

4.6.3 Study selection

Titles and abstracts of all retrieved studies were downloaded onto EndNote X7 citation management software (Thomson Reuters, Philadelphia, PA, USA). After removal of duplicates, two authors (AR and AG) independently assessed all records for eligibility criteria. If a decision could not be made based on abstract text, the full text was retrieved.

Any disagreements were resolved by discussion and a third reviewer consulted if necessary (MAF).

4.6.4 Data collection process and data items

A data collection form was developed to extract the following details: author, year and country, target population, inclusion criteria, recruitment methods, study population, study design, and baseline characteristics; description of intervention including focus, setting, theoretical construct, study arms, delivery method and personnel, duration; and changes in intake from baseline to post-intervention, attrition rate, comparison of drop-outs, follow-up intervention and sustainability of program. In addition, the name of the tool used for assessment of dairy or calcium was extracted and additional questions were included to conduct a dietary tool quality assessment based on that used in a previous review with no modifications necessary as it is appropriate for dietary assessment of all age groups (Burrows et al.,2012).

Some additional data were extracted for quality assessment (i.e. method of randomization, allocation concealment, blinding and reporting bias) (Higgins et al.,2011). A pilot data extraction was carried out before entering data and changes were made appropriately. The primary author extracted the full text of selected studies with 20% additionally extracted by a second author.

4.6.5 Summary measures and synthesis of results

Standardized Mean Difference (SMD) was used as the summary measure which was deemed to be a suitable measure as the same outcome measure was measured in different ways (i.e. servings of food, mg or amount in grams and it standardizes the results before they are combined in a meta-analysis (Cochrane Handbook for Systematic Reviews of

Interventions,2011b). The outcome of interest was the change in dairy or calcium intake post-intervention. Where possible, information pertaining to intake was recorded (frequency or as servings, mg, cups etc.) pre and post-intervention. The changes in mean and standard deviation, standard error and any associated P values overtime were documented. If standard error was reported, it was converted to standard deviation (Cochrane Handbook for Systematic Reviews of Interventions,2011a). For randomized controlled trials, the magnitude of the intervention outcomes were converted to SMD, using Lipsey and Wilson's web-based calculator (Lipsey and Wilson,2001; Wilson,2001).The magnitude of effect was assessed according to the categories, whereby an effect<0.2 is negligible, between 0.2 and 0.49 is small, 0.5 and 0.8 is medium and >0.8 is large (Cohen,1992).

To pool the outcomes for the meta-analysis, dairy and calcium effect sizes were grouped separately, when sufficient data were available i.e. mean, standard deviation and sample size of treatment and control groups. The analyses were conducted based on a random effects model using the metan command on STATA version 13.1 (StataCorp LP). Heterogeneity between studies was assessed using the I^2 statistic, which examines the percentage of variability between studies that cannot be attributed to sampling variations or chance alone.

4.6.6 Risk of bias assessment

For all randomized controlled trials, the risk of bias was assessed by two review authors using the Cochrane risk of bias assessment tool (Higgins et al.,2011). Five domains were assessed for each study: random sequence generation (selection bias), concealment of allocation methods (selection bias), incomplete outcome data (attrition bias), blinding (performance bias and detection bias) and risk of selective outcome reporting (reporting bias). This was completed as described in the Cochrane Handbook for Systematic Reviews of Intervention Version5.1.0 (Higgins J,2011).

For non-randomized trials, the articles were assessed using the Evidence Analysis Manual developed by the Academy of Nutrition and Dietetics (American Dietetics Association,2005). The tool encompasses 10 validity questions which included the assessment of (i) the clarity of the research question; (ii) whether selection bias was apparent; (iii) whether the study groups were comparable and confounders controlled for; (iv) whether withdrawals were handled adequately; (v) blinding of subjects and investigators; (vi) whether the study protocol was described in sufficient detail; (vii) validity and reliability of measurements to measure outcomes; (viii) whether appropriate statistical analysis was conducted; (ix) whether the conclusion accounts for limitations and biases; and (x) declaration of conflict of interest and funding sources.

The study was rated as low risk of bias if six or more of the validity questions were met (including questions ii, iii, vi and vii). If the study did not meet one or two of the validity questions (ii, iii, vi and vii) but met all others, it would be considered as moderate risk of bias. The study was rated as poor quality if the answer was no to six or more questions (out of 10). Any disagreements of quality rating between the review authors were resolved by discussion. A third researcher opinion was sought, where necessary.

4.6.7 GRADE assessment

The grading of recommendation, assessment, development and evaluation (GRADE) system was applied to evaluate the overall quality of the body of evidence (Atkins et al.,2004). Five domains were assessed for each study to ascribe a quality rating: limitations in study designs; consistency of results; directness of the evidence comparing it to the study populations, intervention design and outcomes; precision of outcomes; and publication bias.

Studies without a control group were not included for GRADE assessment as it was not possible to calculate the effect sizes without a control group. Instead, we assessed whether the

trial was successful in changing dietary behaviour of calcium or dairy and if it included any external validity components.

4.6.8 Rating external validity

The external validity of included studies was conducted based on the criteria for rating external validity designed by Green and colleagues (Green and Glasgow,2006). The assessment encompasses: reach and representativeness of participants; intervention implementation and adoption; and program maintenance and institutionalization.

4.6.9 Quality and validity of dietary assessment tools

The Australian Child and Adolescent Obesity Research Network (ACAORN) scoring method was used to assess the quality and validity of the dietary assessment tool of the included studies (Burrows et al.,2012). The ACAORN tool is applicable to all age groups as it is about the quality of dietary assessment tools, not children specifically.

4.7 Results

4.7.1 Study selection

As shown in Figure 4.1, the searches identified 5217 records after duplicates were removed. After the titles and abstracts were screened for relevance, 99 studies were identified for full text examination. From these, 83 were excluded from this review because they did not meet the inclusion criteria. Reasons for exclusion of these studies are provided in Appendix 4.2. A total of 16 studies were included in this review and summarized in Table 4.2–4.4. The studies were classified as RCT's (n=8), non-randomized controlled trials (n=2) and before and after study design (n=6).

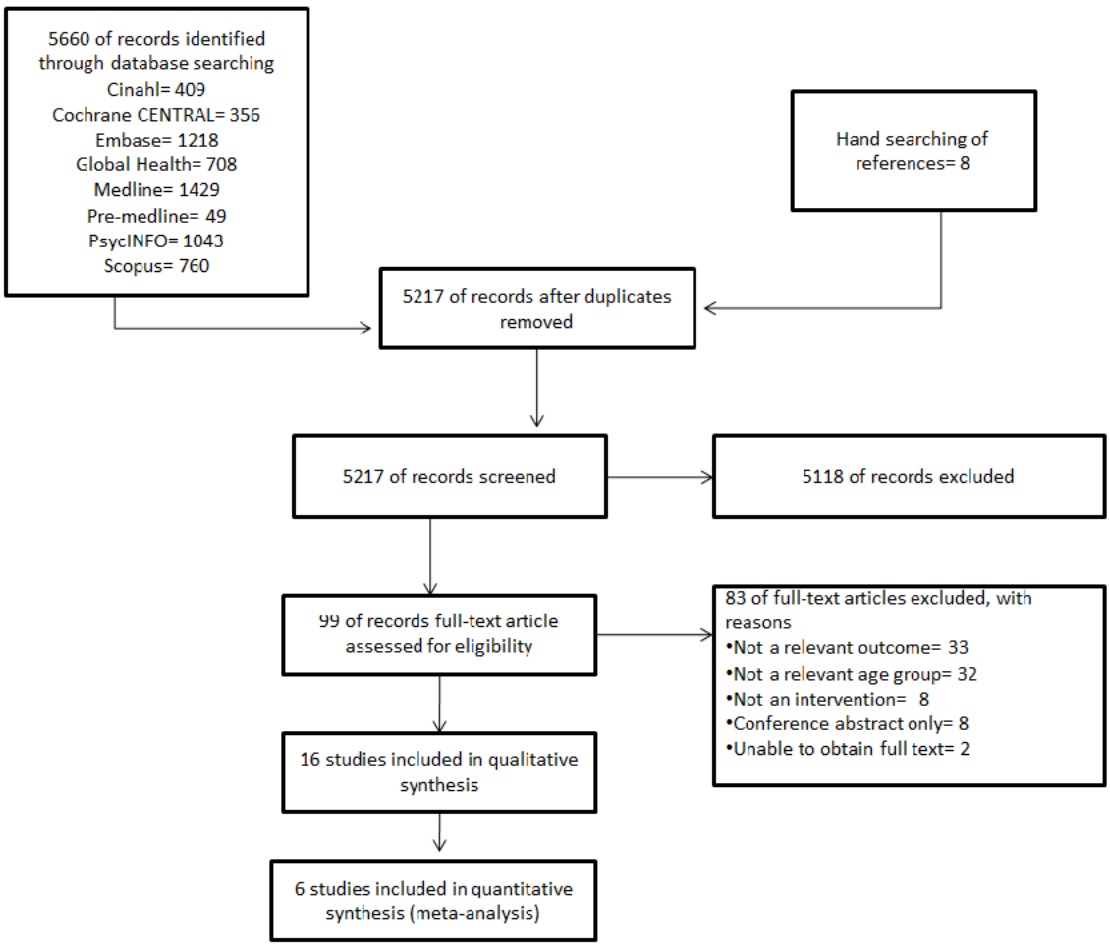

Figure 4.1 Flow diagram showing selection of studies

Table 4.2 Reach and representativeness of participants

Author, year, country, citation	Target population	Inclusion criteria	Recruitment methods	Participation	Study design and study arms (n)	Baseline demographics (mean ± SD)
(Bohaty et al., 2008), USA	Young females	Aged 19-30 years, not currently pregnant or breastfeeding and able to speak, read and write English	Information flyers posted at hairdressing school, a fitness centre and a day care centre.	NR	B&A I: 80 No control group	Age: 22.3±3.1 Sex: all females Ethnicity: 98% Caucasian Other: 74% freshmen
(Ehlert, 2010), USA	College students	Part of the Education Opportunities Fund (EOF) program at University	Email sent to EOF students	NR	RCT I: 40 C: 38	Age: 18 years: 81% Sex: 64% females Ethnicity: I: 50% Black or AA C: 50% Hispanic or Latino
(Gerend and Shepherd, 2013), USA	College women	Undergraduate women	From on campus laboratory	NR	Non-RCT 141 (group numbers not provided)	Age: 18.45±0.86 Sex: all females Ethnicity: 82% White
(Ha et al., 2009), USA	College students	Healthy, 18-24 years and enrolled in basic nutrition class	Sophomore level nutrition class	NR	B&A I: 90 No control group	Age: 20.15±1.38 Sex: 88% females Ethnicity: 90% White BMI: 26.3±5.63
(Jung et al., 2011), Canada	College women	Female, less than 19 years of age, living in university residence and consuming less than DRI for calcium (as reported in a FFQ)	Conducted during a campus club fair at McMaster University	290 women met criteria	RCT I: 67 C: 66	Age: I: 18.4±0.66 C: 18.6±0.55 Sex: all females
(Koszewski et al., 1990), USA	College women	Female undergraduate students	Notice posted in school newspapers and newsletters and personal student contacts in sororities, dormitories and classes.	PP: 22,000 PR: 0.6% 5000 contacted	RCT I: 68 C: 62	Age: 20±3 Sex: all females Other: 32% freshmen
(Kwon and Chang, 2000), Korea	College students	Students enrolled in a basic nutrition course	Participants of a basic nutrition course	NR	B&A I: 187 No control group	Age: 20.0±2.3 Sex: 79% females BMI: 20.2±2.3

Author, year, country, citation	Target population	Inclusion criteria	Recruitment methods	Participation	Study design and study arms (n)	Baseline demographics (mean ± SD)
(Martinelli, 2013), Italy	College sports students	University scholarship athletes	From a pool of recipients of a university scholarship	PP: 105 PR: 6.7%	B&A I: 7 No control group	Age: 21.6±2.4 Sex: 57% females BMI: 25.4±2.3
(Peterson et al., 2000), USA	Young females	Aged 18-30 years with low baseline calcium intake (<700 mg/day)	Television and newspaper advertisements/flyers distributed at the local businesses and Psychology Department	255 responded to recruitment	RCT I: 62 C: 60	Age: I: 21.6±3.8 C: 21.1±2.9 Sex: all females Ethnicity: 33% minority
(Peterson et al., 2010), USA	College students	18-23 years, have a meal plan with residence hall dining and eat at least 3 meals at the dining hall weekly	Surveys distributed in person during lunch and dinner and person entering the cafeteria were invited.	PP: 19,878 PR: 1.4%	B&A I: 288 No control group	Age: 19.58±1.365 Sex: 36% females Ethnicity: 61% White/ Caucasian 27% AA
(Poddar et al., 2010), USA	College students	No exclusion criteria	Recruited from an undergraduate elective personal health course	PP: 997 PR: 29.5%	RCT I: 148 C: 146	Age: I: 20.2±1.3 C: 20.2±1.5 Sex: 55% females Ethnicity: 82% White 11% Asian/ Pacific Islander
(Poddar et al., 2012), USA	College students	Enrolled in health-related classes, 980 eligible to participate, no exclusion criteria	Recruitment announcement on course website, descriptive flyer emailed to students and direct recruitment during lectures	PP: 980 PR: 21.5%	RCT I: 107 C: 104	Age: 20.2±0.1 Sex: 57% females Ethnicity: 73% White
(Shahril et al., 2013), Malaysia	College students	18-24 years, actively using mobile phone, first or second year diploma or degree from management studies, healthy and able to read, write and understand Malay or English	Students recruited from class lists based on eligibility criteria	NR	RCT I: 205 C: 212	Age: I: 19.2±1.1 C: 19.0±1.2 Sex: 81% females

Author, year, country, citation	Target population	Inclusion criteria	Recruitment methods	Participation	Study design and study arms (n)	Baseline demographics (mean ± SD)
(Sueta and Fukuda, 1995), Japan	College women	Students taking a dietitian course	Students taking a dietitian course	NR	Non-RCT I: 54 C: 54	Age: 18 or 19 Sex: all females
(Sueta, 2000), Japan	College women	Students taking a dietitian course	Students taking a dietitian course	NR	Non-RCT I: 54 C: 54	Age: 18-19 Sex: all females
(Talpade and Caddell, 2015), USA	College students	African American students	Enrolled in a research class	NR	B&A I: 40 No control group	Age: 18-26 Sex: 80% females Ethnicity: all AA BMI: 25.71

NR= not reported
B&A= before and after study design
I= intervention
BMI= body mass index;
PP= population pool
PR= participant rate
RCT= randomised controlled trial
C= Control
AA= African American
DRI= dietary reference intake
FFQ= food frequency questionnaire
Non-RCT= Non-randomised controlled trial
BMD= bone mineral density

Table 4.3 Intervention implementation and adoption

Author, year, citation	Intervention								
	Mode of contact	**Frequency of contact**	**Setting**	**Dietary focus**	**Description**	**Theoretical construct**	**Study arms**	**Personnel**	**Duration (including follow-up)**
(Bohaty et al., 2008), USA	Face-to-face	10 sessions 1 f/u call at 8 wks post-intervention	Community	Calcium and dairy only	45-min slide show presentation followed by group discussion, follow-up phone call and handouts;	SCT	I: educational intervention to increase calcium, vitamin D and dairy No control group	Nurses	>8 wks (NR)
(Ehlert, 2010), USA	Face-to-face	4 sessions held every 3 wks	University	Calcium, dairy and other	Four sessions delivered in 1.5 hour segments; face-to-face session followed by discussion, questionnaire	SCT	I: SNAAKS curriculum C: non-nutrition curriculum	Questionnaire reviewed by nutrition and curriculum experts	14 wks
(Gerend and Shepherd, 2013), USA	Face-to-face, handouts	One-off session 1 f/u at 1 mo post-intervention	University	Calcium only	Participants were given 6 mins to read a pamphlet and received handouts to take home	Gain and loss framed messaging	I_1: gain-framed pamphlet I_2: loss-framed pamphlet	NR	~1 mo (NR)
(Ha et al., 2009), USA	Face-to-face	3 times per week	University	Dairy and calcium only	Traditional lecture with interactive activities. Participants met 3 times a week for 50 mins and completed a "Happy Body Log" to encourage behavior changes	NR	I: class-based nutrition intervention No control group	NR	Spring Semester, ~15-16 weeks (NR)
(Jung et al., 2011), Canada	Face-to-face	One-off session, f/u by mail 7 and 24 wks post-intervention	University	Calcium only	45 min seminar followed by second mail-delivered intervention: OSC's 'Speaking of Bones' presentation and two pamphlets	HBM	I: 20 gain-framed messages C: 11 loss-framed messages	Registered dietitian presented the seminar	52 wks

Author, year, citation	Intervention								
	Mode of contact	**Frequency of contact**	**Setting**	**Dietary focus**	**Description**	**Theoretical construct**	**Study arms**	**Personnel**	**Duration (including follow-up)**
(Koszewski et al., 1990), USA	Face-to-face	One-off session, food intake recorded 4 wks post-intervention	University	Calcium and other	15 min slide-tape presentation with Q&A session at the end	NR	I: slide-presentation C: no presentation	Data collection by trained graduate and undergraduate students	1 mo
(Kwon and Chang, 2000), Korea	Face-to-face	NR	University	Dairy and other	Basic level nutrition course at the university	NR	I: nutrition course No control group	NR	Questionnaire collection for ≥2 wks (NR)
(Martinelli, 2013), Italy	Face-to-face, email	6 sessions over 5 mo	University	Calcium and other	Six sessions with interactive workshops on topics relevant to sports nutrition. Group emails sent for meeting times and other program details	NR	I: nutrition education programme No control group	Qualified sports nutrition professional and performance nutritionist	5 mo
(Peterson et al., 2000), USA	Face-to-face	3 sessions, f/u lab visit at 3 and 6 mo + call reminder before an appointment	University	Calcium only	Three calcium intervention sessions in small groups, explaining osteoporosis, sources of calcium and assessing change in intake	NR	I: behavioral/ nutrition intervention C: no intervention	NR	6 mo
(Peterson et al., 2010), USA	Paper	3 reminder emails sent out to record food intake	University	Dairy and other	A logo “The Right Stuff!” was created at point-of-selection to promote healthy foods. Card showing healthy choices and flyers/ signs distributed in the area.	NR	I: point-of-selection intervention No control group	Content validity by registered dietitians	3 wks

Author, year, citation	Intervention								
	Mode of contact	**Frequency of contact**	**Setting**	**Dietary focus**	**Description**	**Theoretical construct**	**Study arms**	**Personnel**	**Duration (including follow-up)**
(Poddar et al., 2010), USA	Electronic, online and email	Daily emails for the first 3 wks, then once every wk for the final 2 wks	University	Dairy only	Online course; posted information, behavior checklists and tailored feedback.	SCT	I: web-based nutrition education C: no intervention	Doctoral student in nutrition and 3 registered dietitians	5 wks
(Poddar et al., 2012), USA	Electronic / online + face-to-face (optional)	Weekly- one module/ per wk. Social event held fortnightly (optional)	University	Dairy only	Online course management system (specifically developed for the study). Participants asked to complete weekly behavior checklists and social events providing nutrition education.	HBM	I: dairy intervention based on SCT C: stress management intervention	A registered dietitian attended social events session to provide education and practical tips on increasing dairy	8 wks
(Shahril et al., 2013), Malaysia	Face-to-face, electronic/ text messaging	A total of 13 text messages sent every 5 days	University	Calcium, dairy and other	Multimodal intervention: conventional lectures, brochures and text messaging used	NR	I: multimodal intervention C: no intervention	Nutrition and public health s developed key messages, diet history and data analysis performed by a nutritionist	10 wks
(Sueta and Fukuda, 1995), Japan	Face-to-face	One-off session, food intake recorded 1 wk and 1 yr post-intervention	University	Calcium only	National survey results shown, participants learnt to self-evaluate their eating pattern and set goals, 40 min videotape on why calcium is necessary and taught how to eat enough in their diet (Basic Foods List)	NR	I: calcium education C: no intervention	Basic Foods List developed by dietitians	12 mo

Author, year, citation	Intervention								
	Mode of contact	**Frequency of contact**	**Setting**	**Dietary focus**	**Description**	**Theoretical construct**	**Study arms**	**Personnel**	**Duration (including follow-up)**
(Sueta, 2000), Japan	Face-to-face	One-off session, food intake recorded 1 wk and 1 yr post-intervention	University	Calcium only	National survey 1991 results shown, participants learnt to self-evaluate their eating pattern and set goals. Education videotape on calcium intake screened and taught how to eat enough calcium in diet (Basic Foods List)	NR	I: calcium education C: no intervention	Video shown developed by a group of dietitians	12 mo
(Talpade and Caddell, 2015), USA	Face-to-face	Weekly sessions held over 2 wks, food intake recorded 3 mo post-intervention	University	Dairy and other	Two 50-min information sessions over two weeks;	Trans-theoretical stages of change model + theory of reasoned action	I: HEALTH intervention No control group	NR	4 mo

F/u= follow-up
SCT= Social Cognitive Theory
I= intervention
Wks= weeks
NR= not reported
MI- motivational interviewing
C= Control
Yrs= years
SNAAKS= Student Nutrition Action, Attitude, Knowledge and Skills
OSC= Osteoporosis Society of Canada
HBM= Health Belief Model
Q&A= Question and answer
GBTL= game-based team learning
CDAS= cloud diet assessment system

Table 4.4 Study results and maintenance

Author, year, citation	Baseline to post-intervention		Effect size (Cohen's d)	Attrition	Compared drop outs	Follow-up
(Bohaty et al., 2008), USA	Calcium: mg Pre: 961.3±477 Post: 905.0±510 P= 0.38 (NS)	Dairy: cups Pre: 0.7278±0.82 Post: 0.8608±0.88 P: 0.14 (NS)	NA, no control group	NR	NR	Yes, at wk 2 (phone call) wk 8 (dietary intake).
(Ehlert, 2010), USA	Calcium: Calcium-rich food servings Pre: I: 2.35±1.18 C: 2.42±1.44 Post: I: 2.42±1.45 C: 2.47±1.24 P: 0.020	Dairy: frequency/day Pre: I: 0.765 ±1.84 C: 1.54 ±4.13 Post: I: 1.51 ±2.77 C: 0.901 ±1.66 P: 0.800 (NS)	Calcium: -0.037 Dairy: 0.265	Nil	NR	NR
(Gerend and Shepherd, 2013), USA	B= 0.29 No further information provided		No control vs. intervention mean and SE/SD for calculation	11% (n=15)	Yes, non-completers were similar to completers for all demographics	Yes, participants returned one month after intervention to provide intake data.
(Ha et al., 2009), USA	Calcium: mg Pre: 813.18±501.48 Post: 858.21±373.11	Total milk: fl.oz Pre: 5.40±9.57 Post: 6.43±11.27 P: 0.433 (NS) Milk: S, NR (females only)	No control vs. intervention mean and SE/SD for calculation	11% (n=10) No control group	NR	NR
(Jung et al., 2011), Canada	Calcium intake (mg): Pre: I: 927±369 C: 891±286 Post: I: 1144±514 C: 813±286 P: <0.01		Calcium: 0.787	I: 24% (n=16) C: 29% (n=19)	NR	Yes, at week 8 (mail-delivered intervention), week 25 (mail-delivered intervention) and week 52 (diet assessment).

Author, year, citation	Baseline to post-intervention		Effect size (Cohen's d)	Attrition	Compared drop outs	Follow-up
(Koszewski et al., 1990), USA	Calcium: mg Pre: I: 93±62 C: 116±73 Post: I: 99±71 C: 96±56 P> 0.05 (NS)		Calcium: 0.047	NR	NR	NR
(Kwon and Chang, 2000), Korea		Milk and dairy foods: mg Pre: Males: 484.9±232.5 Females: 405.0±233.3 Post: Increase in females, amount, NR Milk & dairy: S, NR (females only)	No control vs. intervention mean and SE/SD for calculation	NR	NR	NR
(Martinelli, 2013), Italy	Calcium: mg Pre: 924.9±365.1 Post: 1112.5±826.2 P: 0.510 (NS)		No control vs. intervention mean and SE/SD for calculation	Nil	NR	NR
(Peterson et al., 2000), USA	Dietary calcium intake: Pre: I: 418.17±136.94 C: 470.15±155.81 Post: I: 725.82±334.28 C: 634.16±302.44 Follow-up I: 755.28±305.25 C: 676.96±315.00 P: <0.001		Calcium: 0.253	34% (n=42)	Yes, drop-outs had a significantly lower baseline calcium intake compared to those who completed the study	Yes, at 3 and 6 mo for diet assessment.

Author, year, citation	Baseline to post-intervention	Effect size (Cohen's d)	Attrition	Compared drop outs	Follow-up
(Peterson et al., 2010), USA	Cottage cheese: P= 0.001 (correlation significant at the p≤0.01 level) Skim milk P: NR, NS	Calcium:	I: 64% (n=184) No control group	NR	NR
(Poddar et al., 2010), USA	Dairy: total dairy (servings/ day) Pre: I: 1.5±1.16 C: 1.4±1.17 Post: NR P: NR, NS	No control vs. intervention mean and SE/SD for calculation	I: 9% (n=13) C: 7% (n=10)	NR	NR
(Poddar et al., 2012), USA	Dairy: Pre: servings/day I: 1.37±0.95 C: 1.97±0.94 Post: adjusted I: 0.17±7.78 C: -0.13±7.45 P: 0.01	Dairy: 0.039	I: 16% (n=17) C: 14% (n=15)	NR	NR

Author, year, citation	Baseline to post-intervention		Effect size (Cohen's d)	Attrition	Compared drop outs	Follow-up
(Shahril et al 2013), Malaysia	Calcium: Pre: I: 312.6±100.1 C: 331.4±103.8 Post: I: 376.5±125.4 C: 300.6±116.5 P: <0.001	Dairy products: Pre: I: 0.11±0.27 C: 0.05±0.14 Post: I: 0.13±0.27 C: 0.06±0.14 P: 0.005 Milk: Pre: I: 0.08±0.27 C: 0.09±0.28 Post: I: 0.26±0.40 C: 0.09±0.28 P: <0.001	Calcium: 0.629 Dairy: 0.332 Milk: 0.498	I: 13% (n=27) C: 5% (n=10)	Higher dropout rate in males (16%) vs females (8%)	NR
(Sueta and Fukuda, 1995), Japan	Calcium (mg): Pre: I: 474 C: 494 Post: I: 516 C: 491 P: <0.05		No SD or SE reported for calculation	Nil	NA	Yes, at one year to collect dietary intake.
(Sueta, 2000), Japan	Calcium (mg): Pre: I: 474.4 C: 494.2 Post: I: 418.8 C: 409.7 P>0.05 (NS)		No SD or SE reported for calculation	I: 1% (n=1) C: 0	Only one person dropped out	Yes, at one year to collect dietary intake

Author, year, citation	Baseline to post-intervention	Effect size (Cohen's d)	Attrition	Compared drop outs	Follow-up
(Talpade and Caddell, 2015), USA	Inter-item correlation matrix for dairy: 1.000 No further information reported	No SD or SE reported for calculation	33% (n=13)	NR	NR

Pre= prior to receiving intervention
Post= post-intervention
NS= not significant
NA= not applicable
NR= not reported
Wks= weeks
I= intervention
C= control
S= significant
Yrs= years

Table 4.5 Overall assessment of quality in 6 studies (1091 participants) of promotion of calcium or dairy intake using Grading of Recommendations Assessment, Development and Evaluation (GRADE) system (Atkins et al., 2004)

Category	Rating with reasoning
Limitations	-2 quality level due to serious limitations
Consistency	-1 quality level due to high heterogeneity score
Directness	No subtraction of levels, as the population, outcomes and study design are direct
Precision	-1 quality level due to small sample size
Publication bias	No subtraction of levels, not reported as it is not possible to detect true symmetry when there are less than 10 studies
Overall quality	Low; our confidence in the effect estimate is limited

Table 4.6 Dietary quality of tools used to measure calcium and dairy intake

Study	Method	Validated tool	Dietary score: calculated using ACAORN criteria (Burrows et al., 2012)	
(Bohaty et al., 2008)	Dietary record	No	1.5	Poor
(Ehlert, 2010)	SNAAKS questionnaire	No	3	Acceptable/ reasonable
(Gerend and Shepherd, 2013)	55-item FFQ	Yes (Ilich et al., 1998)	4.5	Good
(Ha et al., 2009)	3-day food record	No	2.75	Acceptable/ reasonable
(Jung et al., 2011)	3-day food record	Yes (Thompson and Byers, 1994)	2	Poor
(Koszewski et al., 1990)	Previous 24-hour food intake	No	1.5	Poor
(Kwon and Chang, 2000)	3-day recall	No	2	Poor
(Martinelli, 2013)	7-day food record	No	2.5	Acceptable/ reasonable
(Peterson et al., 2000)	Hertzler and Frary's rapid assessment questionnaire	Yes (Hertzler and Frary, 1994)	4	Good
(Peterson et al., 2010)	FFQ intake	No	2.25	Acceptable/ reasonable
(Poddar et al., 2010)	7-day food record	No	3.25	Acceptable/ reasonable
(Poddar et al., 2012)	7-day food record	No	2.75	Acceptable/ reasonable
(Shahril et al., 2013)	Dietary recall	No	3.25	Acceptable/ reasonable
(Sueta and Fukuda, 1995)	3-day weighted food record	No	2.25	Acceptable/ reasonable
(Sueta, 2000)	3-day weighted food record	No	2.25	Acceptable/ reasonable
(Talpade and Caddell, 2015)	Capturing meal before and after photo	No	1	Poor

4.7.2 Study reach and representativeness of participants

As shown in Table 4.2, all studies were conducted between1990 and 2015. Over half of the studies were conducted in the United States (n=10), two studies in Japan, and one study each in Canada, Korea, Italy and Malaysia. The total number of participants included in this review was 2434 with a mean of 152 participants per study (range: 7 to 417). The mean participation rate was 11.9% (range: 0.6% to 29.5%). The study population tended to be of higher education, female (81.1%) and Caucasian background which limited the representativeness of the population; the mean age was 19.9 years (range: 18.4 to 22.3 years). For studies that reported ethnicity (n=9), the populations with the highest representation included White or Caucasian (n=6) and a minority included African American, Hispanic or Latino (n=3). A majority of the studies described their target audience as 'college or university students' (n=9), one of which specifically targeted university sports scholar students, and only a few studies targeted the general population (n=3).

4.7.3 Intervention implementation and adaption

Eleven studies focused on improving dairy or calcium as their primary focus and the remaining studies targeted multiple food groups or nutrients. Ten studies promoted calcium, six targeted dairy and four measured both (Bohaty et al.,2008; Ehlert,2010; Ha et al.,2009; Shahril and Lua,2013).

As shown in Table 4.3, the majority of the studies were conducted in a university setting (n=15), with one study conducted in the community (Bohaty et al.,2008). The majority of the studies provided face-to-face delivery of information (n=12). This included lecture style delivery (n=5) (Bohaty et al.,2008; Ha et al.,2009; Jung et al.,2011; Shahril and Lua,2013), tape or video presentation (Koszewski et al.,1990; Sueta, 2000; Sueta and Fukuda,1995). Four studies reported including a discussion or interactive activity component (Ehlert,2010;

Ha et al.,2009; Koszewski et al.,1990; Martinelli,2013). Three studies reported on providing pamphlet, brochures or handouts (Gerend and Shepherd,2013; Jung et al.,2011; Shahril and Lua,2013). One study provided a nutrition course in a class setting (Kwon and Chang,2000), and one study provided education in small groups (Petersonetal.,2000). One study used phone calls as part of their intervention (Bohaty et al.,2008), and one study used text messaging (Shahril and Lua,2013). Two studies used group emails and one study used mail-delivery to communicate information.

Six studies delivered a single one-off session with some follow-up contact through mail or telephone, which may be considered as lower intensity intervention (Gerend and Shepherd,2013; Jung et al.,2011; Koszewski et al.,1990; Peterson et al.,2010; Sueta,2000; Sueta and Fukuda,1995). Six studies provided multiple sessions over the course of the intervention. Four studies provided contact on a weekly or daily basis which was classed as higher intensity (Ha et al.,2009; Poddar et al.,2012; Poddar et al.,2010; Shahril and Lua,2013). Psychological theory-based constructs were used in 6 studies and included: Social Cognitive Theory (SCT) (Ehlert,2010; Poddar et al.,2010), Health Belief Model (HBM) (Jung et al.,2011; Poddar et al.,2012), or a combination of Transtheoretical or Stage of Change and Theory of Reasoned Action (Talpade and Caddell,2015). Four studies incorporated goal-setting as part of their intervention (Ehlert,2010; Poddar et al.,2012; Sueta,2000; Sueta and Fukuda,1995), one of which provided feedback to participants.

The mean length of intervention was 18.25±18.0 weeks (range: 3 weeks to 1 year). Over half of the studies had a duration of less than six months (n=12). Three studies had duration of one month or less (Gerend and Shepherd,2013; Koszewski et al.,1990; Peterson et al.,2010). Four studies had a duration of one year or more (Jung et al.,2011; Sueta,2000; Sueta and

Fukuda,1995). Few studies did not clearly specify the duration; the length of intervention was estimated from the details, where possible.

4.7.4 Study maintenance and institutionalization

Most studies reported on intake at baseline and post-intervention in sufficient detail (Table 4.4). Calcium intake was measured in mg or calcium-rich servings and dairy amount was reported in servings and frequencies. Of 10 studies with a control group, six studies reported a significant difference between intervention and control group (Ehlert,2010; Jung et al.,2011; Peterson et al.,2000; Poddar et al.,2012; Shahril and Lua,2013; Sueta and Fukuda,1995). For studies without a control group, two studies reported no significant difference before and after intervention (Bohaty et al.,2008; Martinelli,2013). Three studies reported a significant difference (Ha et al.,2009; Kwon andChang,2000; Peterson et al.,2010), two of which were in females only (Ha et al.,2009; Kwon and Chang,2000).

Attrition was reported in 10 studies; the mean attrition rate was 21.3%, and ranged from 1% to 64% (see Table 4.4). A majority of the studies did not provide any information comparing drop-out characteristics to completers (n=13). Five studies included follow-up of dietary intake after the intervention (Bohaty et al.,2008; Gerend and Shepherd,2013; Peterson et al.,2000; Sueta,2000; Sueta and Fukuda,1995), while one included continued support via meetings, phone calls or mail-delivered material during the follow-up period (Jung et al.,2011). No studies reported any detail of program sustainability after the intervention research.

4.7.5 Risk of bias

The Cochrane risk of bias assessment is presented in Appendix 4.4. A total of eight studies were included for Cochrane assessment, all of which were RCT's. For the overall judgment,

four studies rated as unclear, three as high and one was low risk. The majority of the studies rated as unclear for selection bias did not describe the method of randomization or concealment of allocation. A majority of the studies rated as low risk had low or no attrition; only two studies were found to have a high attrition rate (>20%) (Jung et al.,2011; Peterson et al.,2000). For performance and detection bias, most studies were rated as low risk as they provided description on blinding or reported an objective measure of outcome. All studies reported pre-specified outcomes; however, one study was rated as unclear or high as there were large baseline differences between intervention and control group for dairy intake (Ehlert,2010).

Results for all non-randomized controlled trials and before and after studies assessed using the American Dietetic Association or ADA tool (n=8) are presented in Appendix 4.5. Six studies were deemed to have a moderate risk of bias and two as high risk. None of the studies blinded the research team or data collectors for assessment of outcomes. Three studies did not conduct appropriate statistical analysis (Kwon and Chang,2000; Martinelli,2013; Talpade and Caddell,2015). One study did not use valid and reliable instruments to measure outcomes (Talpade and Caddell,2015).

4.7.6 GRADE quality rating

Study limitations

Of six studies included in the meta-analysis, the majority of the studies rated were as high risk of bias (n= 3). Two studies described the method for providing randomized sequence generation (Poddar et al.,2012; Shahril and Lua,2013). One study adequately concealed intervention and control groups (Poddar et al.,2012). One study could anticipate allocation as it was explained to participants (Peterson et al.,2000). Three studies described the method of blinding which involved blinding of the principal investigator or research assistants

(Ehlert,2010; Jung et al.,2011; Shahril and Lua,2013). Three studies performed a completer's analysis (Jung et al.,2011; Poddar et al.,2012; Shahril and Lua,2013) and one study performed an intention to treat analysis (Peterson et al.,2000). All but one study reported pre-specified outcomes.

Consistency

The effect size for change in calcium intake yielded an I^2 statistic of 75.1% (p value for heterogeneity=0.003) and I^2 statistic of 53.4% (p value for heterogeneity =0.092) for change in dairy intake. Both of these results indicate moderate heterogeneity (Figure 4.2 and 4.3).

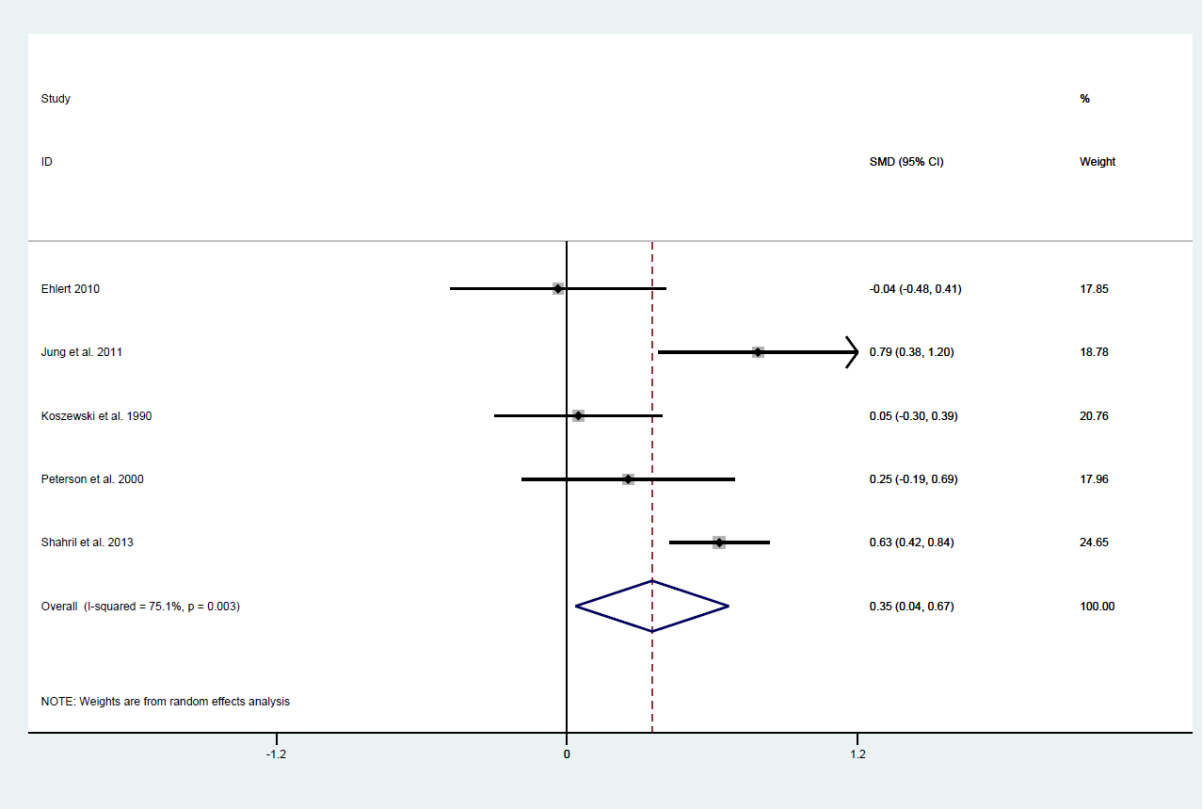

Figure 4.2 A forest plot of Cohen d effect size for interventions reporting calcium intake

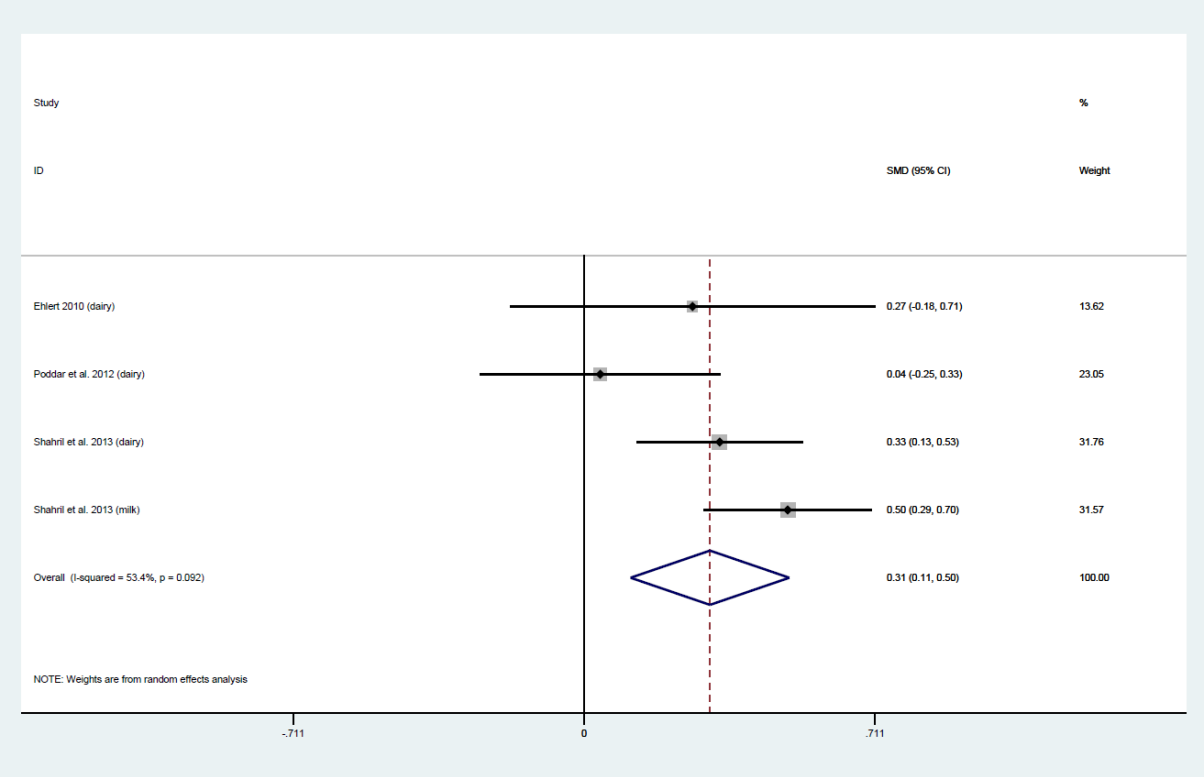

Figure 4.3 A forest plot of Cohen d effect size for interventions reporting dairy intake

Directness

There are variations between study design, population and outcome measures which made it difficult to compare between studies. The majority of population included in our study were college students, and only two interventions recruited beyond the university or college setting (Jung et al.,2011; Koszewski et al.,1990).

Precision

Only three studies reported conducting sample power calculations; however, these were mainly based on Bone Mineral Density (BMD) outcomes rather than calcium or dairy intake. One study calculated power to examine bone density (Jung et al.,2011). The sample size of the population included in the GRADE body of evidence yielded 1091 participants (range 78 to 380), which is considered insufficient.

Publication bias

Whilst an extensive search strategy was conducted to minimize the risk of publication bias, this cannot be ruled out as unpublished or negative finding studies may have been missed. Funnel plot and statistical tests of publication bias were not reported as they are not recommended for meta-analyses less than 10 studies due to the inability to detect true symmetry with fewer studies (Higgins,2011). As shown in Table 4.5, overall body of evidence was rated as low due to the study limitations, heterogeneity and small sample size in the included studies. Out of six studies included in the meta-analysis, one scored low risk of bias, three as unclear and two were high risk, which indicates serious limitations.

4.7.7 Efficacy of interventions

Of the 16 reviewed studies, 10 studies provided results for calcium and eight studies provided results on dairy intake. Four studies included results for both calcium and dairy intake. Studies targeting calcium intake appear to be slightly more successful than dairy intake. For calcium, five studies were included in the meta-analysis; four of which reported positive effects (SMD 0.05–0.79, four were statistically significant). The pooled effect size was 0.35 (95% CI 0.04 to 0.67); all studies contributed similar weighting (ranged from17.85% to 24.65%).

For dairy, three studies were included in the meta-analysis; all of which reported positive effects (SMD 0.04–0.50, two were statistically significant). The pooled effect size was 0.31 (95% CI 0.11 to 0.50). Contributing weighting of studies ranged from 13.62 to 31.76%).

4.7.8 Quality and validity of dietary assessment tools

As shown in Table 4.6, over half of the studies scored as acceptable/reasonable (n=9). Five studies were rated as poor and two studies rated good. The mean score was 2.5, and ranged from 1 to 4.

Of the reviewed studies, the most common method of assessing intake was food record (n=8) and three studies used a dietary recall. Five used tools that were specific to the study such as questionnaires, FFQs (Food Frequency Questionnaire) and capturing photos of meals. Three studies used a FFQ, one of which had been validated previously in a similar population (Gerend and Shepherd,2013), and one conducted a test-retest of the instrument (Peterson et al.,2010). A majority of the studies did not acknowledge appropriate validation studies in relation to the use of their tool; (Hertzler and Frary,1994; Ilich et al.,1998; Thompson and Byers,1994) and only three studies provided details of a validation study in sufficient detail (Gerend and Shepherd,2013; Jungetal.,2011; Petersonetal.,2000).

4.8 Discussion

To our knowledge, this is the first systematic review of interventions of calcium or dairy intake among young adults. Our findings suggest that calcium or dairy interventions may have a small effect on increasing intake, as indicated by the meta-analyses. However, findings must be interpreted with caution, due to the presence of heterogeneity and poor quality of the intervention studies.

Education was reported as the most widely used technique to change behavior. It was previously suggested in the literature that knowledge of calcium was related to intake of dairy foods (Nicklas,2003). While knowledge is important, it is apparent that knowledge on its own

is not sufficient for a behaviour change to take place (Brug et al.,2005; Jepson et al.,2010). Participants must be taught the 'how to' aspect of behavior change (Worsley,2002). Research has established the importance of incorporating a behavior change theory in the intervention (Brug et al.,2005). Half of the studies included a theoretical construct or a behavior change technique in their intervention, but of these only four of seven had positive outcomes. Self-efficacy is often thought to be the best predictor of engagement in a particular behavior (Hackman and Knowlden,2014), but it is reported that there are two phases of self-efficacy motivational and volitional in healthy eating and both need to be high for behavior change (Ochsner et al.,2013). This may be why only three of five studies addressing self-efficacy were successful. A meta-regression examining successful behavior change techniques for adopting healthy eating and physical activity in adults revealed that self-monitoring combined with at least one other technique from control theory such as goal-setting and feedback was more effective (Michie et al.,2009). Four studies used goal-setting and two of these resulted in positive behaviour changes, one of which also used self-monitoring.

Among the studies that improved dairy or calcium intake, only small changes were observed. Several studies reported the increase being significant but still inadequate compared to dietary guidelines. The benefits resulting from behavioral modification to improve calcium intake may only be evident over time, however the long-term effectiveness of the interventions in the current review cannot be determined since only seven studies included a follow-up. They will only reap the benefits if the behavior modifications are sustained and a longer follow-up is required to determine this. It is necessary to address any barriers, as well as beliefs and myths concerning dairy foods consumption. Future studies may benefit from addressing barriers to dairy consumption in order to address long-term behavior change, as stated in a recent review (Hendrie et al.,2013).

From our assessment of dietary tools, it is evident that some uncertainty remains in the quality of the tools used. In order to assess shortfalls in a population, an accurate measurement is required. An earlier review by Magarey et al emphasized the need to develop better quality tools to assess calcium and dairy foods intake (Magarey et al.,2014); our findings from this review are in agreement. The studies included in this review are of uncertain quality as a majority of the papers did not conduct blinding of investigators and participants or ensure random allocations or concealment or blinding of assessors. However, two studies rated scored as high quality, both of which were effective.

The degree to which the interventions can be translated to the broader young population is poor, as a majority of our studies recruited from a university or college setting. Most of the studies were conducted in western countries and used convenience sampling. Even though the latest statistics show a greater proportion of young adults entering tertiary education (OECD,2016), young people in lower socioeconomic status remain underrepresented (Centre for the Study of Higher Education,2008). This gap could be addressed by recruiting outside the tertiary sector in the community at large.

None of our studies provided information of sustainability or costs; therefore, the external validity remains unclear. Numerous systematic studies have emphasized the lack of external validity in the field of public health research (Blackman et al.,2013; Klesges et al.,2008; Laws et al.,2012; Nour et al.,2016; Partridge et al.,2015). In order to upscale interventions and translate into the wider community, studies need to report on external validity components, particularly program sustainability and cost-effectiveness.

Interventions which were of higher intensity (i.e. provided weekly or daily contact) did not perform any better compared to interventions that were of low intensity (only one point of contact) or moderate intensity. This is consistent with a recent review (Racey et al.,2016),

which included children from 9 to 18 years in a school setting. Face-to-face contact was the most widely used method for delivery of the interventions, however, with increasing use of technology; a small number of interventions incorporated an electronic component. Recent reviews one-health or m-health interventions for other dietary behaviors have shown promising results (Free et al.,2013; Nour et al.,2016). A recent review targeting dairy food intake in adolescents found that interventions were successful without providing an individual contact (Marquez et al.,2015). This is an important consideration as it means group delivery of an intervention may be sufficient when targeting this age group, resulting in lower costs. Earlier reviews have pointed out the lack of electronic interventions in this field of research (Marquez et al.,2015; Ryan et al.,2013). There is the potential to explore the use of electronic technologies in interventions to improve intake of dairy products, as they are a convenient and possibly cost-effective alternative to traditional modes (Steinhubl et al.,2015).

Three studies in our review included a form of electronic technology, two of which were successful and incorporated face-to-face contact, which indicated that some human contact may be important. It may be worth focusing on a discrete nutritional behavior rather than trying to change numerous behaviors (Hendrie et al.,2013; Jung et al.,2016; Sweet and Fortier,2010). Targeting one nutrition behavior may be more manageable for the participants as they are likely to view it as seemingly minor and manageable compared to a global change in diet (Jung et al.,2016).

Future studies could consider online-technology based interventions because they can double the number of users as opposed to an average public health campaign (10% vs. 5% respectively) (Cugelman,2013). With the rise of the internet as a source of nutritional and medical information and high ownership of smartphone in young adults, these may be appropriate channels to deliver health promotion (Kite et al.,2016; Pollard et al.,2015).

Furthermore, smartphones are becoming very popular, young adults having the highest smartphone ownership and a recent US survey has revealed that 85% young adults are smartphone user and almost three-quarters have used their smartphone to look up health information (Pew Research Center, 2015). There have already been a number of successful interventions addressing other nutritional behaviors using this media to promote nutritional behavior (Allman-Farinelli et al.,2016; Coughlin et al.,2015; Nour et al.,2017; Olson,2016).

This review has several strengths which include a comprehensive search strategy, adherence to PRISMA protocol for selection of studies (Moher et al.,2009), and a meta-analysis for dairy foods and calcium intake. In addition, two reviewers conducted a risk of bias and GRADE assessment to assess the overall body of evidence. The limitations of the included studies are the dietary tools used to measure dietary intake and overall poor quality of studies. The limitations of the search strategy include filtering studies that were only published in English and those indexed in major databases. While attempts were made to search grey literature, the possibility of publication bias cannot be ruled out. Finally, the considerable differences in the intensity of the interventions made it difficult to make direct comparisons between the studies.

In conclusion, our review revealed some evidence demonstrating that calcium and dairy interventions are effective; however, poor quality of studies and moderate heterogeneity remain a limitation. Future interventions could include a form of electronic technology, self-monitoring, goal-setting and social support for increasing intake. Greater rigor is needed in terms of reporting external validity components and improving quality of interventions in order to confidently determine their effectiveness and cost-effectiveness for dissemination to the population-at-large. The findings of this review may be used to inform the development

of future interventions targeting young adults for increased calcium and dairy intake to optimal levels.

4.9 References

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4.10 Conclusion to chapter

The available evidence base is comprised of studies that were not very effective at improving calcium intake. The majority of interventions were delivered in a traditional manner, with only three studies that included a form of technology. As mentioned in Chapter Two, young adults are high users of technology so it may be beneficial to develop an intervention using an electronic platform. Two behaviour change techniques were identified (goal-setting and self-monitoring) in this chapter which resulted in positive behaviour change and should be included in future interventions. Overall, a small effect size was found and the quality of the body of evidence was low. The systematic review did not find any Australian studies so it was necessary to delve into formative research prior to developing an intervention. The next two chapters will synthesise qualitative and quantitative research conducted with the target population.

Appendix 4

Appendix 4.1: Search strategy for all databases searches (in alphabetical order)

CINAHL via EBSCO search strategy

S1 MH Young adult
S2 MH Student health education
S3 MH Students, college
S4 "Young adult*"
S5 "Young person*"
S6 "Young people"
S7 "Young" W2 (adult* OR person* OR people)
S8 "University student*"
S9 "Youth*"
S10 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9
S11 MH Dairy products+
S12 MH Calcium
S13 "Dairy*"
S14 "Milk"
S15 "Yoghurt*"
S16 "Yogurt*"
S17 "Cheese*"
S18 S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17
S19 MH Telehealth
S20 MH Text messaging
S21 MH Social Media
S22 MH Mobile applications
S23 MH Internet+
S24 MH Computer systems
S25 MH Therapy, Computer Assisted
S26 MH Electronic mail
S27 MH Cellular Phone+
S29 MH Smartphone
S30 MH Telemedicine
S31 "e-health"
S32 "ehealth"
S33 "m-health"
S34 "mhealth"
S35 "Mobile health"
S36 "Text*"
S37 "SMS*"
S38 "Health messag*"
S39 "Electronic health"
S40 "Mobile app*"
S41 "Mobile phone*"
S42 "Computer based"
S43 "Email"
S44 "Telecommunication"
S45 "Electronic communication"
S46 "Smartphone*"
S47 MH Home visits
S48 MH Adolescent Nutrition
S49 MH Education

S50 MH Health Education
S51 MH Education, Dietetics
S52 MH Nutrition Education
S53 MH Nutritional Counseling
S54 "Individual session*"
S55 "Group session*"
S56 "Phone call*"
S57 “Dietary intervention*”
S58 "Dietary program*"
S59 "Nutrition education*"
S60 "Nutrition intervention*"
S61 "Nutrition program*"
S62 "Education program*"
S63 "Intervention*"
S64 S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63
S66 S12 AND S20 AND S65
Limiters- Human
Narrow by Language- English

Cochrane Central Register of Controlled Trials (CENTRAL) via OvidSP

ID	Search
#1	MeSH descriptor: [Young Adult] explode all trees
#2	Students
#3	Young* near/2 (adult* or person* or people) .mp
#4	College student* .mp
#5	University student* .mp
#6	Youth* .mp
#7	#1 or #2 or #3 or #4 or #5 or #6
#8	MeSH descriptor: [Dairy Products] explode all trees
#9	Calcium, dietary
#10	Dairy* .mp
#11	Milk .mp
#12	Yogurt* .mp
#13	Yoghurt* .mp
#14	Cheese* .mp
#15	#8 or #9 or #10 or #11 or #12 or #13 or #14
#16	Telemedicine
#17	Smartphone
#18	Text Messaging
#19	Electronic Mail
#20	MeSH descriptor: [Internet] explode all trees
#21	Mobile Applications
#22	MeSH descriptor: [Cell Phones] explode all trees
#23	Telephone
#24	Reminder Systems
#25	Social Networking
#26	(ehealth or e-health) .mp
#27	(mhealth or m-health) .mp
#28	Telehealth .mp
#29	Text* .mp

#30 SMS .mp
#31 Health messag* .mp
#32 Social media .mp
#33 Electronic health .mp
#34 Mobile app* .mp
#35 Mobile phone* .mp
#36 Mobile health .mp
#37 Computer based .mp
#38 Email .mp
#39 Telecommunication .mp
#40 Electronic communication .mp
#41 Smartphone* .mp
#42 Information Dissemination
#43 Computer Systems
#44 Diet
#45 Diet Records
#46 Education, Distance
#47 Food Habits
#48 Social Control, Informal
#49 Social Support
#50 Health education
#51 Nutritional Sciences
#52 Health Promotion
#53 Education
#54 Health Communication
#55 Individual session* .mp
#56 Group session* .mp
#57 Phone call* .mp
#58 Dietary intervention* .mp
#59 Dietary program* .mp
#60 Nutrition intervention* .mp
#61 Nutrition education* .mp
#62 Nutrition program* .mp
#63 Education program* .mp
#64 Intervention* .mp
#65 #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or # or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64
#66 #7 and #15 and #65
#67 Limit to Trials

Embase via OvidSP

1. exp Young adult/
2. (Young* adj2 (adult* or person* or people)).mp.
3. College student*.tw.
4. University student*.tw.
5. Youth*.tw.
6. or/1-5
7. exp Dairy product/
8. Calcium deficiency/
9. exp Calcium intake/

10. Dairy*.tw.
11. Milk.tw.
12. Yoghurt*.tw.
13. Yogurt*.tw.
14. Cheese*.tw.
15. or/9-14
16. exp Telehealth/
17. Calcium deficiency/
18. Mobile phone/
19. Computer assisted therapy/
20. Computer program/
21. Internet/
22. Telecommunication/
23. Mass communication/
24. Text messaging/
25. Mobile application/
26. Health education/
27. Social media/
28. Mass medium/
29. Telephone/
30. Computer system/
31. E-mail/
32. (ehealth or e-health).tw.
33. (mhealth or m-health).tw
34. Mobile health.tw.
35. Telehealth.tw.
36. Telemedicine.tw.
37. Text*.tw.
38. SMS.tw.
39. Health messag*.tw.
40. Computer based.tw.
41. Email*.tw.
42. Electronic health.tw.
43. Electronic Communication.tw.
44. Smartphone*.tw.
45. Education program/
46. Learning/
47. Nutrition education/
48. Education/
49. Nutritional education/
50. School health education/
51. Health promotion/
52. Health Literacy/
53. Individual session*.tw.
54. Group session*.tw.
55. Phone call*.tw.
56. Dietary intervention*.tw.
57. Dietary program*.tw.
58. Nutrition education*.tw.
59. Nutrition intervention*.tw.
60. Nutrition program*.tw.
61. Education program*.tw.
62. Intervention*.tw.
63. or/18-62

64. 6 and 15 and 63
65. limit 64 to human
66. **limit 65 to english language**

Global Health via OvidSP

1. young adults/
2. college students/
3. students/
4. youth/
5. (Young* adj2 *(adult* or person* or people)).mp
6. University student*.tw.
7. or/1-6
8. exp milk products/
9. milk consumption/
10. calcium/
11. Dairy*.tw.
12. or/9-11
13. mobile telephones/
14. telecommunications/
15. internet/
16. computers/
17. ehealth.tw.
18. mhealth.tw.
19. e-health.tw.
20. m-health.tw.
21. mobile health.tw.
22. telehealth.tw.
23. telemedicine.tw.
24. text*.tw.
25. SMS.tw.
26. health messag*.tw.
27. social media.tw.
28. electronic health.tw.
29. mobile app*.tw.
30. computer based.tw.
31. email*.tw.
32. electronic Communication.tw.
33. smartphone*.tw.
34. youth programmes/
35. dietary history/
36. nutrition education/
37. nutrition knowledge/
38. nutrition programmes/
39. preventive nutrition/
40. diet/
41. diet counseling/
42. diet studies/
43. diet treatment/
44. individual session*.tw.
45. group session*.tw.
46. phone call*.tw.
47. dietary intervention*.tw.

48. dietary program*.tw.
49. nutrition education*.tw.
50. nutrition intervention*.tw.
51. nutrition program*.tw.
52. education program*.tw.
53. or/14-52
54. 7 and 12 and 53
55. limit 54 to english language

Pre-Medline via OvidSP

1. (Young* adj2 (adult* or person* or people)).mp.
2. College student*.mp.
3. University student*.mp.
4. Youth*.mp.
5. or/1-4
6. Dairy*.mp.
7. Milk.mp.
8. Yogurt.mp.
9. Yoghurt.mp.
10. Cheese*.mp.
11. or/7-10
12. ehealth.mp.
13. mhealth.mp.
14. mobile health.mp.
15. e-health.mp.
16. m-health.mp.
17. Telehealth.mp.
18. telemedicine.mp.
19. Text*.mp.
20. SMS.mp.
21. Health messag*.mp.
22. Social media.mp.
23. electronic health.mp.
24. Mobile app*.mp.
25. Mobile phone*.mp.
26. Internet.mp.
27. Computer based.mp.
28. Email.mp.
29. telecommunication.mp.
30. Electronic Communication.mp.
31. Smartphone*.mp.
32. Individual session*. mp.
33. Group session*.mp.
34. Phone call*.mp.
35. Dietary intervention.mp.
36. Dietary program*.mp.
37. Nutrition intervention*.mp.
38. Nutrition education*
39. Nutrition program*.mp.
40. Education program*.mp.
41. Intervention*.mp
42. or/13-41
43. 5 and 11 and 42

PsycINFO via OvidSP

1. Predelinquent Youth/
2. (Young* adj2 (adult* or person* or people)).tw.
3. College student*.tw.
4. University student*.tw.
5. Youth*.tw
6. or/1-5
7. Food Intake/
8. Calcium/
9. Food Preferences/
10. Diets/
11. Nutrition /
12. Dairy*.tw.
13. Yogurt*.tw.
14. Yoghurt*.tw
15. Milk.tw.
16. Cheese*.tw.
17. or/7-16
18. Telemedicine/
19. Internet/
20. exp Social media/
21. Health Promotion/
22. Technology/
23. Electronic Communication/
24. Health Literacy/
25. Health Behavior/
26. Messages/
27. exp Mobile Devices/
28. Computer Mediated Communication/
29. Telephone Systems/
30. (mhealth or m-health).tw.
31. (ehealth or e-health).tw.
32. Electronic health.tw
33. mobile health.tw.
34. Mobile app*.tw.
35. Mobile phone*.tw.
36. Computer based.tw.
37. email*.tw.
38. Text*.tw.
39. SMS.tw.
40. Smartphone*.tw.
41. Telecommunication.tw.
42. Health messag*.tw.
43. School Based Intervention/
44. Health Education/
45. Health Knowledge/
46. Behavior Change/
47. Intervention/
48. Education/
49. Educational Programs/
50. Individual session*.tw.
51. Group session*.tw.
52. Phone call*.tw.

53. Dietary intervention*.tw.
54. Dietary program*.tw.
55. Nutrition program*.tw.
56. Nutrition program*.tw.
57. Nutrition education*.tw.
58. Nutrition intervention*.tw.
59. Education program*.tw.
60. or/18-59
61. 6 and 17 and 60
62. limit 61 to english language

Scopus

((TITLE-ABS-KEY (dairy*)) OR (TITLE-ABS-KEY (milk)) OR (TITLE-ABS-KEY (yogurt)) OR (TITLE-ABS-KEY (yoghurt)) OR (TITLE-ABS-KEY (cheese)) OR (TITLE-ABS-KEY (calcium))) AND (TITLE-ABS-KEY (young* W/2 (adult* OR person* OR people))) OR (TITLE-ABS-KEY ("College student*")) OR (TITLE-ABS-KEY ("University student*")) OR (TITLE-ABS-KEY (youth*))) AND (((TITLE-ABS-KEY (mhealth) OR TITLE-ABS-KEY ({m-health}) OR TITLE-ABS-KEY (ehealth) OR TITLE-ABS-KEY ({e-health}) OR TITLE-ABS-KEY ({mobile health}) OR TITLE-ABS-KEY (telehealth) OR TITLE-ABS-KEY (telemedicine) OR TITLE-ABS-KEY ("text messag*") OR TITLE-ABS-KEY (sms) OR TITLE-ABS-KEY ("health messag*") OR TITLE-ABS-KEY ({social media}) OR TITLE-ABS-KEY ({electronic health}) OR TITLE-ABS-KEY ("mobile app*") OR TITLE-ABS-KEY ("mobile phone*") OR TITLE-ABS-KEY ({computer based}) OR TITLE-ABS-KEY (email) OR TITLE-ABS-KEY (telecommunication) OR TITLE-ABS-KEY ({electronic communication}) OR TITLE-ABS-KEY (smartphone*) OR TITLE-ABS-KEY (internet))) OR ((TITLE-ABS-KEY ("individual session*") OR TITLE-ABS-KEY ("group session*") OR TITLE-ABS-KEY ("phone call*"))) OR ((TITLE-ABS-KEY (diet* W/2 (program* OR intervention*))) OR (TITLE-ABS-KEY (nutrition* W/2 (program* OR education* OR intervention*))))) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Human")

Appendix 4.2 Reasons for exclusion

Author, year	Reason for exclusion
1. Alameda 2013	Not a relevant outcome (no dairy)
2. Alamri et al 2015	Conference abstract only
3. Allen et al 2007	Not a relevant outcome (no dairy)
4. Arts et al 2014	Conference abstract only
5. Banks 2011	Not a relevant age group (participants 12-14 years)
6. Bogart 2014	Not a relevant outcome (no dairy)
7. Bogart et al 2011	Not a relevant outcome (no dairy)
8. Brinberg et al 2000	Not a relevant outcome (no dairy)
9. Bronner et al 2006	Not an intervention
10. Brown 2014	Not a relevant outcome (no dairy)
11. Brown et al 2005	Not a relevant outcome (no dairy)
12. Buscher et al 2001	Not a relevant outcome (not measuring intake, sales data only)
13. Caine et al 2006	Not a relevant age group (participants up to sixth graders)
14. Carson 2011	Not a relevant age group (participants 11-15 years)
15. Casazza & Ciccazzo 2007	Not a relevant age group (participants 13-18 years)
16. Cason et al 2002	Not a relevant age group (includes population 19-50 years)
17. Chan et al 2005	Not a relevant age group (includes women 18-46+ years)
18. Chan & Ko 2006	Not a relevant age group (includes women 18-46+ years)
19. Cox et al 2003	Not a relevant age group (includes 15-52 years)
20. Cullen et al 2013	Not a relevant age group (includes 12-17 years)
21. Davis et al 2013	Not a relevant outcome (no dairy)
22. DeBar et al 2004	Not a relevant age group (includes 14-16 years)
23. DeBar et al 2006	Not a relevant age group (includes 14-16 years)
24. DeBar et al 2009	Not a relevant age group (includes 14-16 years)
25. Dewar et al 2013	Not a relevant outcome (no dairy)
26. Drieling et al 2011	Not a relevant age group (includes 45-85 years)
27. Esterlydia & John 2011	Not a relevant outcome (intervention only measures nutrition knowledge and awareness)
28. Fernandes 2014	Conference abstract only
29. Franke 1989	Unable to obtain full text (abstract only)
30. Gates et al 2013	Not a relevant age group (includes 10-15 years)
31. Gates et al 2013 (different to above)	Not a relevant age group (includes 11-16 years)
32. Hekler et al 2010	Not a relevant outcome (targets decrease of high fat dairy)
33. Ikeda et al 2002	Not a relevant age group (includes women 15-46)
34. Kebaili et al 2014	Not a relevant age group (includes 12-16 years)
35. Kemirembe 2010	Not a relevant age group (includes 10-14 years)
36. Kershaw 2001	Not a relevant outcome (no dairy)
37. Kwon & Chang 2000	Not an intervention
38. LaChausse 2012	Not a relevant outcome (no dairy)
39. Mackey et al 2015	Not a relevant outcome (no dairy)
40. Magee et al 2008	Not a relevant age group (includes adolescents)
41. Matthews et al 2014	Not an intervention
42. Matvienko et al 2001	Not a relevant outcome (no dairy)
43. McDonnell et al 1997	Not an intervention
44. McKinley 2003	Not an intervention

45. Melnyk et al 2007	Not a relevant outcome (no dairy)
46. Meyers et al 2012	Conference abstract only
47. Miller 1988	Not a relevant outcome (no dairy)
48. Miller et al 1995	Not an intervention
49. Mobley et al 2012	Not a relevant outcome (no dairy)
50. Nabi & Thomas 2013	Not a relevant outcome (no dairy)
51. Nourse et al 2015	Not a relevant age group (includes 10-19 years)
52. Olson et al 2008	Not a relevant age group (includes ≤14)
53. Panek et al 2013	Not a relevant outcome (no dairy)
54. Peng 2009	Not a relevant outcome (no dairy)
55. Prochaska & Sallis 2004	Not a relevant outcome (no dairy)
56. Purcell et al 2013	Conference abstract only
57. Radvanyi 2015	Unable to obtain full text (abstract only)
58. Rafferty et al 2009	Not a relevant age group (includes younger school children) check with Amanda
59. Randi Schoenfeld et al 2010	Not a relevant outcome (only intention to change)
60. Reed et al 2002	Not a relevant age group (includes 11-15 years)
61. Reger et al 1998	Not a relevant outcome (targets decrease of high fat dairy)
62. Rhodes et al 2010	Not a relevant age group (includes 9-14 years)
63. Ritchie 2012	Not a relevant outcome (no dairy)
64. Robinson 2014	Not a relevant outcome (no dairy)
65. Rose et al 2014	Conference abstract only
66. Rose et al 2015	Conference abstract only
67. Roth-Yousey 2012	Not a relevant age group (includes 9-13 years)
68. Rukstalis et al 2010	Conference abstract only
69. Sanaeinsasab et al 2013	Not a relevant age group (includes 15-16 years)
70. Scripa 2013	Not a relevant outcome (no dairy)
71. Shilts et al 2004	Not a relevant outcome (no dairy)
72. Shilts et al 2009	Not a relevant outcome (only intention to change)
73. Shin et al 2015	Not a relevant outcome (no dairy)
74. Skinner et al 2012	Not a relevant age group (includes grade 6 to 10)
75. Sneha et al 2014	Not a relevant age group (includes girls 13-16 years)
76. Snelling et al 2006	Not an intervention
77. Stark et al 2005	Not a relevant age group (includes 4-10 years)
78. Ulavannavar & Usha 2015	Not a relevant outcome (no dairy)
79. van Nassau et al 2014	Not a relevant outcome (no dairy)
80. Walsh et al 2003	Not a relevant age group (includes 16-109 years)
81. Watson et al 2009	Not a relevant age group (includes 14-19 years)
82. Weems 1987	Not an intervention
83. Yang et al	Not a relevant age group (includes 15-16 years)

Appendix 4.3 full version of dietary quality scoring assessment measuring calcium and dairy intake of included studies

Study	Document study tool	Is there a dietary method validation study?	Document validation tool 1. Validation study sample and sample size 2. Statistics to assess validity	3. Data collection	4. Scoring method	Question 5 and 6 (specific to method)	Total score
(Bohaty et al., 2008)	"3-day dietary recall" Dietary record	Generic citation	-	Done by participants: 0	Nutritionist Five Software: 1	3 days: 0.5	1.5 Poor
(Ehlert, 2010)	SNAAKS questionnaire	Yes, based on other validated questionnaires for similar audiences	-	?	Sub-scale provided: 1	Provided as an appendix + summary of items: 0.5 + 0.5	3 Acceptable/ reasonable
(Gerend and Shepherd, 2013)	55-item FFQ	Yes, Ilich et al 1998(Ilich et al., 1998)	1. same population + ~450 girls: 0.5 + 0.5 2. mean + adjusted correlation: 1 + 1	Researcher administered: 0.5	0	Frequency scale + portion size: 0.5 + 0.5	4.5 Good
(Ha et al., 2009)	3-day food record	N/A	-	Checked by researchers: 0.5	NutriBase IV Clinical: 1	Multiple days, weekdays and weekends, measuring utensils for portion size 0.5 + 0.5 + 0.25	2.75 Acceptable/ reasonable
(Jung et al., 2011)	3-day food record	Yes(Thompson and Byers, 1994)	Not relevant	0	Nutritionist Five: 1	Multiple days, weekdays and weekends: 0.5 + 0.5	2 Poor
(Koszewski et al., 1990)	"Previous 24-hour food intake"	No	-	Researcher administered: 0.5	Nutrient adequate ratios (NARS) (Guthrie & Screener 1981): 1	No further details provided: 0	1.5 Poor

Study	Document study tool	Is there a dietary method validation study?	Document validation tool 1. Validation study sample and sample size 2. Statistics to assess validity	3. Data collection	4. Scoring method	Question 5 and 6 (specific to method)	Total score
(Kwon and Chang, 2000)	3-day recall	No	-	Researcher administered: 0.5	Computer-Aided nutritional program for professionals: 1	Multiple days: 0.5	2 Poor
(Martinelli, 2013)	7-day food record	No	-	Researcher administered + checked for accuracy: 0.5	NetWISP V.3.0 Dietary Analysis Software: 1	Multiple days + weekends: 0.5 + 0.5	2.5 Acceptable/ reasonable
(Peterson et al., 2000)	Hertzler and Frary's rapid assessment questionnaire	Yes (Hertzler and Frary, 1994)	1. same population + ~250: 0.5 + 0.5 2. means + Pearson adjusted: 1 + 0.5	Researcher administered: 0.5	Questionnaire sub-scales: 1	No further details provided: 0	4 Good
(Peterson et al., 2010)	FFQ intake	No	- Test-retest	Researcher administered: 0.5	Valid: 1	FFQ frequency + portion size: 0.5 + 0.25	2.25 Acceptable/ reasonable
(Poddar et al., 2010)	7-day food record	-	-	Researcher administered + reviewed: 0.5 + 0.5	Dietitian calculated dairy products by hand from food records Score: 1	Multiple days + weekends and weekdays + amounts: 0.5 + 0.5 + 0.25	3.25 Acceptable/ reasonable
(Poddar et al., 2012)	7-day food record	-	-	Researcher administered: 0.5	Dairy servings from food records were calculated based on MyPyramid Score: 1	Multiple days + weekends and weekdays + amounts: 0.5 + 0.5 + 0.25	2.75 Acceptable/ reasonable

Study	Document study tool	Is there a dietary method validation study?	Document validation tool 1. Validation study sample and sample size 2. Statistics to assess validity	3. Data collection	4. Scoring method	Question 5 and 6 (specific to method)	Total score
(Shahril et al., 2013)	"7-day diet history" Dietary recall	Yes, cited Nutritional Assessment textbook	-	Researcher administered: 0.5	Nutritionist Pro: 1	Multiple days + weekends + portion size with measurements: 0.5 + 0.5 + 0.25	3.25 Acceptable/ reasonable
(Sueta and Fukuda, 1995)	3-day weighted food record	-	-	Researcher checked for misreporting: 0.5	NNSJ using the food composition table: 1	3 consecutive day + quantitative: 0.5 + 0.25	2.25 Acceptable/ reasonable
(Sueta, 2000)	3-day weighted food record	-	-	Researcher checked for misreporting: 0.5	NNSJ using the food composition table: 1	3 consecutive day + quantitative: 0.5 + 0.25	2.25 Acceptable/ reasonable
(Talpade and Caddell, 2015)	Capturing meal before and after photo	No	-	-	'My gov' template: 1	-	1 Poor

Appendix 4.4 Cochrane Collaboration Risk of Bias summary for bias of randomized controlled trials (n=8)

First author, year	Selection bias				Attrition bias		Performance bias and detection bias		Reporting bias		Overall judgement
	Random sequence generation		Allocation concealment		Incomplete outcome data		Blinding of outcomes		Selective reporting		
	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	
(Ehlert, 2010)	Unclear risk	Participants were randomly assigned to intervention or control.	Unclear risk	Method not described	Unclear risk	Not reported	Low risk	The principal investigator was blinded to the randomisation process	Unclear risk	All pre-specified outcomes were reported. Control and intervention groups were different at baseline for dairy.	Unclear
(Gerend and Shepherd, 2013),	Unclear risk	Method of randomisation not described	Unclear risk	Method not described	Low risk	Intention to treat analysis (comparison of completer and non-completers). Numbers provided but reasons not reported.	High risk	Staff were aware of allocation	Low risk	All pre-specified outcomes were reported	High

First author, year	Selection bias				Attrition bias		Performance bias and detection bias		Reporting bias		Overall judgement
	Random sequence generation		Allocation concealment		Incomplete outcome data		Blinding of outcomes		Selective reporting		
	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	
(Jung et al., 2011)	Unclear risk	Method of randomisation not described	Unclear risk	Method not described	High risk	Completer's analysis (analyses conducted on those present at follow-up). High attrition, numbers provided but reasons not reported.	Low risk	Research assistants were blind to the participant's assignment	Low risk	All pre-specified outcomes were reported	High
(Koszewski et al., 1990)	Unclear risk	Method of randomisation not described.	Unclear risk	Different rooms were used for experimental and control groups	Low risk	All participants remained in the study	Low risk	Objective outcome measure	Low risk	All pre-specified outcomes were reported	Unclear
(Peterson et al., 2000)	Unclear risk	Method of randomisation not described	High risk	Participants could anticipate allocations prior to treatment	Unclear	Intention to treat analysis (comparison of completer and non-completers). High attrition, numbers provided and reasons reported.	High risk	Participants were aware of study outcome and self-reported data	Low risk	All pre-specified outcomes were reported	High
(Poddar et al., 2010)	Unclear risk	Method of randomisation not described	Unclear risk	Method not described	Low risk	Attrition comparable between groups	Low risk	Objective outcome measure	Low risk	All pre-specified outcomes were reported	Unclear

First author, year	Selection bias				Attrition bias		Performance bias and detection bias		Reporting bias		Overall judgement
	Random sequence generation		Allocation concealment		Incomplete outcome data		Blinding of outcomes		Selective reporting		
	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	Cochrane judgement	Supporting evidence	
(Poddar et al., 2012)	Low risk	Randomised using a random number generator	Low risk	Participants could not anticipate as intervention is web-based	Low risk	Completer's analysis (analyses conducted on those present at follow-up). Numbers provided and reasons reported. Attrition comparable between groups	Low risk	Objective outcome measure	Low risk	All pre-specified outcomes were reported	Low
(Shahril et al., 2013)	Low risk	Randomised by drawing sealed envelopes containing group assignment	Unclear risk	Safeguards for concealment not described	Unclear risk	Completer's analysis (analyses conducted on those present at follow-up). Numbers provided but reasons not reported. Attrition not comparable between groups.	Low risk	Nutritionist was blinded to the group history data for diet history analysis. Diet history was used to measure outcomes.	Low risk	All pre-specified outcomes were reported	Unclear

Appendix 4.5 Risk of bias using the ADA tool used for non-randomised trials and before and after study designs (n=8)

Authors	1	2	3	4	5	6	7	8	9	10	Overall
	Research question	Selection of units	Comparability of units	Withdrawals	Blinding	Intervention and intervening factors	Outcomes	Statistics	Conclusions	Funding	Risk of bias
(Bohaty et al., 2008)	Yes	Yes	NA	NA	No	Yes	Yes	Yes	Yes	Unsure	Moderate risk
(Ha et al., 2009)	Yes	Yes	NA	NA	No	Yes	Yes	Yes	Yes	Yes	Moderate risk
(Kwon and Chang, 2000)	Yes	Yes	NA	Yes	No	Yes	Yes	No	Yes	Yes	Moderate risk
(Martinelli, 2013)	Yes	No	NA	NA	No	Yes	Yes	No	No	Unsure	High risk
(Peterson et al., 2010)	Yes	Yes	NA	NA	NA	Yes	Yes	Yes	Yes	Yes	Moderate risk
(Sueta and Fukuda, 1995	Yes	Unclear	Yes	NA	No	Yes	No	Yes	Yes	Unsure	Moderate risk
(Sueta, 2000)	Yes	Unclear	No	NA	No	Yes	No	Yes	Yes	Unsure	Moderate risk
(Talpade and Caddell, 2015)	Yes	Yes	NA	Yes	No	Yes	No	No	Yes	Yes	High risk

Appendix 4.6

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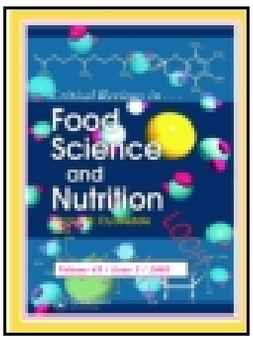
DOI: 10.1080/10408398.2017.1336508

(See next page)



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Assessing the efficacy and external validity of interventions promoting calcium or dairy intake in young adults: A systematic review with meta-analysis

Anika S. Rouf, Amanda Grech & Margaret Allman-Farinelli

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Assessing the efficacy and external validity of interventions promoting calcium or dairy intake in young adults: A systematic review with meta-analysis

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ABSTRACT

Calcium and dairy products have a role in the prevention of chronic diseases and attainment of peak bone mass, during adolescence to young adulthood. However, intakes are often suboptimal and interventions to improve consumption of food sources are needed. This systematic review aimed to investigate the efficacy and external validity of interventions promoting calcium or dairy foods among young adults. Eight databases were searched from inception to identify relevant studies. Inclusion criteria included those aged 18 to 35 years in an intervention promoting calcium or dairy food intake. The mean age of the participants was 19.9 ± 1.4 years. Of the 16 studies that met the selection criteria, five studies were included in the meta-analyses for calcium (pooled effect size 0.35, 95% CI 0.04 to 0.67) and three studies for dairy (pooled effect size 0.31, 95% CI 0.11 to 0.50). The quality of the body of evidence was determined using the GRADE system, and was of overall low quality with high risk of bias. Our review suggests young adults respond favorably to interventions but the effect size is small.

KEYWORDS

Calcium; dairy; young adults; interventions; behavior change

Introduction

Dairy foods provide the major source of calcium in the Australian diet along with other essential micronutrients including protein, vitamins (A, B12, and riboflavin) and minerals (P, Mg, K, and Zn) (Weaver, 2009; Yantcheva et al., 2016). Calcium and dairy products have a role in the maintenance of good health and prevention of chronic disease (Larson et al., 2009), and are recommended in the dietary guidelines in many countries (Ebeling Peter et al., 2013; National Health and Medical Research Council, 2013; Nations, 2016; U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015).

There is a growing body of evidence connecting dairy foods consumption with improved health outcomes, through improved weight control (Doidge and Segal, 2012; Dougkas et al., 2011). Two or more servings of dairy foods consumption per day was associated with reduced risk of ischemic heart disease and myocardial infarction (Elwood et al., 2008; Elwood et al., 2004; National Health and Medical Research Council, 2011), and associated with reduced risk of stroke (Alvarez-Leon et al., 2006; de Goede et al., 2016; National Health and Medical Research Council, 2011). Three servings of low fat dairy products are associated with reduced risk of hypertension (McGrane et al., 2011; National Health and Medical Research Council, 2011). Increased dairy foods consumption may also be inversely associated with insulin resistance syndrome, also known as metabolic syndrome or syndrome X (Martins et al., 2015; Pereira et al., 2002), and reducing type two diabetes (Elwood et al., 2008; National Health and Medical Research Council, 2011; Pereira et al., 2002; Pittas et al., 2007).

Despite the established benefits of dairy products and alternatives for chronic disease prevention, it still remains a reluctant choice among adults. In the latest survey results in Australia, 90% of the Australian population (aged two years and over) do not consume enough dairy foods (Australian Bureau of Statistics, 2016). They are commonly consumed by children (Australian Bureau of Statistics, 2012), but statistics suggest that the intake of dairy products and alternatives decrease during adolescence (Baird et al., 2012; Parker et al., 2012). From the latest Australian Nutrition and Physical Activity Survey (NNPAS) 2011–12, almost 45% of males and 70% of females aged 19 to 30 years have inadequate calcium intakes (Australian Bureau of Statistics, 2015). This raises some concern as sufficient intake of calcium is necessary, particularly during adolescence and young adulthood, to maximize peak bone mass (Matkovic, 1992), and increasing dairy intake may displace the consumption of energy-dense, high-fat foods and soft drinks (Rampersaud et al. 2003; Rangan et al., 2012; Vartanian et al., 2007).

The transition to adulthood is a period often associated with developing more autonomy over dietary choices (Allman-Farinelli et al., 2016). Young adulthood is a vulnerable time, as they are entering new environments (i.e. moving out of home, starting college or university) and gaining independence from their parents (Deshpande et al., 2009). These changes may lead to engagement in risky behaviors and reduced concern about their future

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Trial registration: http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42016035908

well-being (Harhay and King, 2012). Consequently, they are vulnerable to developing lifelong unhealthy behaviors (Ha et al., 2009). This is concerning, given that the habits formed can have a substantial effect in later life but also for future generations (Gore et al., 2011). Therefore, it is important that this group be targeted separately to instill healthy behaviors (National Health and Medical Research Council, 2015; Nour et al., 2016).

Previous systematic reviews have focused on interventions on dairy foods and calcium consumption in children and adolescents (Hendrie et al., 2013; Marquez et al., 2015), or in elderly adults at risk of developing osteoporosis (Kastner and Straus, 2008; Little and Eccles, 2010; Lock et al., 2006). There has been little research on effective lifestyle programmes in the young adult age group (Hebden et al., 2012; National Health and Medical Research Council, 2015). In the recent years, there has been a shift towards electronic interventions due to rising use of technology to promote better health (Kohl et al., 2013). To date, there is no published review investigating the effectiveness of calcium and dairy interventions in young adults. In order to translate interventions into the broader young adult population, it is essential to examine the external validity which is considered as important as efficacy (Steckler and McLeroy, 2008). Therefore, the aim of this review was to examine the efficacy of dairy and calcium interventions targeting young adults and assess the quality of the studies and external validity components reported.

Methods

Protocol and registration

The review has been registered with Prospero (Registration number: CRD42016035908). The PRISMA guidelines were used in the synthesis of the review (Moher et al., 2009).

Eligibility criteria

Criteria for inclusion included young adults, defined as those aged 18 to 35 years, as this is considered the acceptable range based on the National Institute of Health cut-offs (National Institutes of Health, 2010) in an intervention that promoted calcium or dairy intake, with or without a comparison group. The outcome of measure was change in calcium or dairy intake at baseline and post-intervention. The outcome could be reported in servings or frequencies. Randomized controlled trials (RCTs), quasi-experimental design, and before and after studies with a primary or secondary aim to increase calcium or dairy intake were included. Comparison was made between baseline and follow-up, as well as between intervention and control group. Control group may be no intervention or minimal contact.

Information sources

A systematic search was conducted using the following academic databases: Cinahl, Embase, Global Health, Medline, Pre-Medline, PsycINFO, Scopus and The Cochrane Library. These databases were searched from inception to 22nd May 2017 to select relevant articles. A search strategy for Medline was developed first and revised appropriately for each database. A combination of subject and keyword search was used to retrieve more relevant papers. For subject searching, relevant terms were searched on all databases and subject headings were chosen (where relevant). For example, 'telemedicine' was found on Medline thesaurus Medical Subject Headings (MESH) which encompasses the terms 'mHealth', 'eHealth', 'telehealth' and 'mobile Health'. The keyword search terms for interventions were broad, including electronic ('email', 'texting', 'mobile phones', 'smartphones') and non-electronic interventions ('nutrition intervention', 'health education', 'nutrition education', 'dietary records').

No restriction limit was used on databases except for language (English) and studies involving 'humans' (where applicable). The complete search strategy in the electronic database Medline is presented in Table 1 (refer to supplementary tables for full search strategy). Additional studies were retrieved by hand searching the reference list of relevant studies.

Study selection

Titles and abstracts of all retrieved studies were downloaded onto EndNote X7 citation management software (Thomson Reuters, Philadelphia, PA, USA). After removal of duplicates, two authors (AR and AG) independently assessed all records for eligibility criteria. If a decision could not be made based on abstract text, the full text was retrieved. Any disagreements were resolved by discussion and a third reviewer consulted if necessary (MAF).

Data collection process and data items

A data collection form was developed to extract the following details: author, year and country, target population, inclusion criteria, recruitment methods, study population, study design, and baseline characteristics; description of intervention including focus, setting, theoretical construct, study arms, delivery method and personnel, duration; and changes in intake from baseline to post-intervention, attrition rate, comparison of drop-outs, follow-up intervention and sustainability of program. In addition, the name of the tool used for assessment of dairy or calcium was extracted and additional questions were included to conduct a dietary tool quality assessment based on that used in a previous review with no modifications necessary as it is appropriate for dietary assessment of all age groups (Burrows et al., 2012).

Some additional data were extracted for quality assessment (i.e. method of randomization, allocation concealment, blinding and reporting bias) (Higgins et al., 2011). A pilot data extraction was carried out before entering data and changes were made appropriately. The primary author extracted the full text of selected studies with 20% additionally extracted by a second author.

Summary measures and synthesis of results

Standardized Mean Difference (SMD) was used as the summary measure which was deemed to be a suitable measure as

Table 1. Electronic database search: Medline.

Search ID number	Search terms	Results
1	Young Adult/	473361
2	Students/	40762
3	Youth* .tw	41829
4	(Young* adj2 (adult* or person* or people)).tw.	89813
5	College student*.tw.	12779
6	University student*.tw.	7540
7	or/1–6	2009668
8	exp Dairy Products/	79847
9	Calcium, Dietary/	12999
10	or/8–9	91783
11	Telemedicine/	13171
12	Electronic Mail/	2075
13	exp Internet/	57138
14	Mobile Applications/	819
15	exp Cell Phones/	6658
16	Telephone/	9838
17	Reminder Systems/	2550
18	Social Networking/	1337
19	Information Dissemination/	11843
20	Computer Systems/	11937
21	Ehealth*.tw.	762
22	Mhealth*.tw.	342
23	E-health*.tw.	1132
24	M-health*.tw.	108
25	Mobile health.tw.	592
26	Telehealth.tw.	1668
27	Text*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	78307
28	SMS.tw.	3117
29	Health messag*.tw.	1392
30	Social media.tw.	1784
31	Electronic health.tw.	5165
32	Telecommunication.tw.	1013
33	Computer based.tw.	10083
34	Electronic Communication.tw.	561
35	Smartphone*.tw.	1397
36	Diet/	126793
37	Mobile app*.tw.	396
38	Diet Records/	4359
39	Education, Distance/	2903
40	Food Preferences/	10770
41	Social Control, Informal/	3542
42	Social Support/	55800
43	Nutritional Sciences/	10778
44	Food Habits/	24013
45	Health Promotion/	58486
46	Education/	18872
47	Health Communication/	918
48	Health Literacy/	2445
49	Consumer Health Information/	2322
50	Health knowledge, attitudes, practice/	81149
51	Individual session*.tw.	540
52	Group session*.tw.	2242
53	Phone call*.tw.	1711
54	Dietary intervention*.tw.	4298
55	Dietary program*.tw.	144
56	Nutrition intervention*.tw.	1341
57	Nutrition program*.tw.	1636
58	Nutrition education*.tw.	2920
59	Education program*.tw.	19706
60	or/11–59	577665
61	7 and 10 and 60	1469
62	limit 63 to English language	1378

the same outcome measure was measured in different ways (i.e. servings of food, mg or amount in grams and it standardizes the results before they are combined in a meta-analysis (Cochrane Handbook for Systematic Reviews of Interventions, 2011b). The outcome of interest was the change in dairy or calcium intake post-intervention. Where possible, information pertaining to intake was recorded (frequency or as servings, mg, cups etc.) pre and post-intervention. The changes in mean and standard deviation, standard error and any associated P values overtime were documented. If standard error was reported, it was converted to standard deviation (Cochrane Handbook for Systematic Reviews of Interventions, 2011a). For randomized controlled trials, the magnitude of the intervention outcomes were converted to SMD, using Lipsey and Wilson's web-based calculator (Lipsey and Wilson, 2001; Wilson, 2001). The magnitude of effect was assessed according to the categories, whereby an effect <0.2 is negligible, between 0.2 and 0.49 is small, 0.5 and 0.8 is medium and >0.8 is large (Cohen, 1992).

To pool the outcomes for the meta-analysis, dairy and calcium effect sizes were grouped separately, when sufficient data were available i.e. mean, standard deviation and sample size of treatment and control groups. The analyses were conducted based on a random effects model using the metan command on STATA version 13.1 (StataCorp LP). Heterogeneity between studies was assessed using the I^2 statistic, which examines the percentage of variability between studies that cannot be attributed to sampling variations or chance alone.

Risk of bias assessment

For all randomized controlled trials, the risk of bias was assessed by two review authors using the Cochrane risk of bias assessment tool (Higgins J, 2011). Five domains were assessed for each study: random sequence generation (selection bias), concealment of allocation methods (selection bias), incomplete outcome data (attrition bias), blinding (performance bias and detection bias) and risk of selective outcome reporting (reporting bias). This was completed as described in the Cochrane Handbook for Systematic Reviews of Intervention Version 5.1.0 (Higgins J, 2011).

For non-randomized trials, the articles were assessed using the Evidence Analysis Manual developed by the Academy of Nutrition and Dietetics (American Dietetics Association, 2005). The tool encompasses 10 validity questions which included the assessment of (i) the clarity of the research question; (ii) whether selection bias was apparent; (iii) whether the study groups were comparable and confounders controlled for; (iv) whether withdrawals were handled adequately; (v) blinding of subjects and investigators; (vi) whether the study protocol was described in sufficient detail; (vii) validity and reliability of measurements to measure outcomes; (viii) whether appropriate statistical analysis was conducted; (ix) whether the conclusion accounts for limitations and biases; and (x) declaration of conflict of interest and funding sources.

The study was rated as low risk of bias if six or more of the validity questions were met (including questions ii, iii, vi and vii). If the study did not meet one or two of the validity questions (ii, iii, vi and vii) but met all others, it would be considered as moderate risk of bias. The study was rated as poor quality if the answer was no to six or more questions (out of 10). Any disagreements of quality rating between the review authors were resolved by discussion. A third researcher opinion was sought, where necessary.

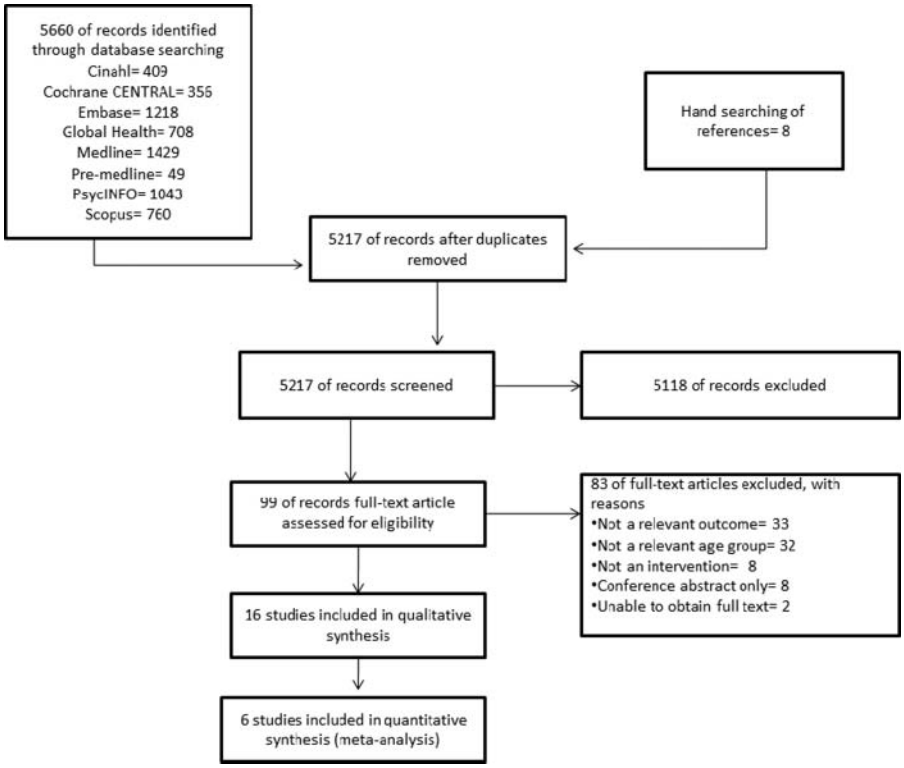

Figure 1. Flow diagram showing selection of studies.

GRADE assessment

The grading of recommendation, assessment, development and evaluation (GRADE) system was applied to evaluate the overall quality of the body of evidence (Atkins et al., 2004). Five domains were assessed for each study to ascribe a quality rating: limitations in study designs; consistency of results; directness of the evidence comparing it to the study populations, intervention design and outcomes; precision of outcomes; and publication bias.

Studies without a control group were not included for GRADE assessment as it was not possible to calculate the effect sizes without a control group. Instead, we assessed whether the trial was successful in changing dietary behavior of calcium or dairy and if it included any external validity components.

Rating external validity

The external validity of included studies was conducted based on the criteria for rating external validity designed by Green and colleagues (Green and Glasgow, 2006). The assessment encompasses: reach and representativeness of participants; intervention implementation and adoption; and program maintenance and institutionalization.

Quality and validity of dietary assessment tools

The Australian Child and Adolescent Obesity Research Network (ACAORN) scoring method was used to assess the quality and validity of the dietary assessment tool of the included studies (Burrows et al., 2012). The ACAORN tool is applicable to all age groups as it is about the quality of dietary assessment tools, not children specifically.

Results

Study selection

As shown in Fig. 1, the searches identified 5217 records after duplicates were removed. After the titles and abstracts were screened for relevance, 99 studies were identified for full text examination. From these, 83 were excluded from this review because they did not meet the inclusion criteria. Reasons for exclusion of these studies are provided in Supporting Information 2. A total of 16 studies were included in this review and summarized in Table 2–4. The studies were classified as RCT's ($n = 8$), non-randomized controlled trials ($n = 2$) and before and after study design ($n = 6$).

Study reach and representativeness of participants

As shown in Table 2, all studies were conducted between 1990 and 2015. Over half of the studies were conducted in the United States ($n = 10$), two studies in Japan, and one study each in Canada, Korea, Italy and Malaysia. The total number of participants included in this review was 2434 with a mean of 152 participants per study (range: 7 to 417). The mean participation rate was 11.9% (range: 0.6% to 29.5%). The study population tended to be of higher education, female (81.1%) and Caucasian background which limited the representativeness of the population; the mean age was 19.9 years (range: 18.4 to 22.3 years). For studies that reported ethnicity ($n = 9$), the populations with the highest

Table 2. Reach and representativeness of participants.

Author, year, country, citation	Target population	Inclusion criteria	Recruitment methods	Participation	Study design and study arms (n)	Baseline demographics (mean ± SD)
(Bohaty et al., 2008), USA	Young females	Aged 19–30 years, not currently pregnant or breastfeeding and able to speak, read and write English	Information flyers posted at hairdressing school, a fitness center and a day care center.	NR	B&A I: 80 No control group	Age: 22.3 ± 3.1 Sex: all females Ethnicity: 98% Caucasian Other: 74% freshmen
(Ehlert, 2010), USA	College students	Part of the Education Opportunities Fund (EOF) program at University	Email sent to EOF students	NR	RCT I: 40 C: 38	Age: 18 years: 81% Sex: 64% females Ethnicity: I: 50% Black or AA C: 50% Hispanic or Latino
(Gerend and Shepherd, 2013), USA	College women	Undergraduate women	From on campus laboratory	NR	Non-RCT 141 (group numbers not provided)	Age: 18.45 ± 0.86 Sex: all females Ethnicity: 82% White
(Ha et al., 2009), USA	College students	Healthy, 18–24 years and enrolled in basic nutrition class	Sophomore level nutrition class	NR	B&A I: 90 No control group	Age: 20.15 ± 1.38 Sex: 88% females Ethnicity: 90% White BMI: 26.3 ± 5.63
(Jung et al., 2011), Canada	College women	Female, less than 19 years of age, living in university residence and consuming less than DRI for calcium (as reported in a FFQ)	Conducted during a campus club fair at McMaster University	290 women met criteria	RCT I: 67 C: 66	Age: I: 18.4 ± 0.66 C: 18.6 ± 0.55 Sex: all females
(Koszewski et al., 1990), USA	College women	Female undergraduate students	Notice posted in school newspapers and newsletters and personal student contacts in sororities, dormitories and classes.	PP: 22,000 PR: 0.6% 5000 contacted	RCT I: 68 C: 62	Age: 20 ± 3 Sex: all females Other: 32% freshmen
(Kwon and Chang, 2000), Korea	College students	Students enrolled in a basic nutrition course	Participants of a basic nutrition course	NR	B&A I: 187 No control group	Age: 20.0 ± 2.3 Sex: 79% females BMI: 20.2 ± 2.3
(Martinelli, 2013), Italy	College sports students	University scholarship athletes	From a pool of recipients of a university scholarship	PP: 105 PR: 6.7%	B&A I: 7 No control group	Age: 21.6 ± 2.4 Sex: 57% females BMI: 25.4 ± 2.3
(Peterson et al., 2000), USA	Young females	Aged 18–30 years with low baseline calcium intake (<700 mg/day)	Television and newspaper advertisements/flyers distributed at the local businesses and Psychology Department	255 responded to recruitment	RCT I: 62 C: 60	Age: I: 21.6 ± 3.8 C: 21.1 ± 2.9 Sex: all females Ethnicity: 33% minority
(Peterson et al., 2010), USA	College students	18–23 years, have a meal plan with residence hall dining and eat at least 3 meals at the dining hall weekly	Surveys distributed in person during lunch and dinner and person entering the cafeteria were invited.	PP: 19,878 PR: 1.4%	B&A I: 288 No control group	Age: 19.58 ± 1.365 Sex: 36% females Ethnicity: 61% White/ Caucasian 27% AA
(Poddar et al., 2010), USA	College students	No exclusion criteria	Recruited from an undergraduate elective personal health course	PP: 997 PR: 29.5%	RCT I: 148 C: 146	Age: I: 20.2 ± 1.3 C: 20.2 ± 1.5 Sex: 55% females Ethnicity: 82% White 11% Asian/ Pacific Islander
(Poddar et al., 2012), USA	College students	Enrolled in health-related classes, 980 eligible to participate, no exclusion criteria	Recruitment announcement on course website, descriptive flyer emailed to students and direct recruitment during lectures	PP: 980 PR: 21.5%	RCT I: 107 C: 104	Age: 20.2 ± 0.1 Sex: 57% females Ethnicity: 73% White
(Shahril and Lua, 2013), Malaysia	College students	18–24 years, actively using mobile phone, first or second year diploma or degree from management studies, healthy and able to read, write and understand Malay or English	Students recruited from class lists based on eligibility criteria	NR	RCT I: 205 C: 212	Age: I: 19.2 ± 1.1 C: 19.0 ± 1.2 Sex: 81% females
(Sueta and Fukuda, 1995), Japan	College women	Students taking a dietitian course	Students taking a dietitian course	NR	Non-RCT I: 54 C: 54	Age: 18 or 19 Sex: all females

(*Continued on next page*)

Table 2. (Continued).

Author, year, country, citation	Target population	Inclusion criteria	Recruitment methods	Participation	Study design and study arms (n)	Baseline demographics (mean ± SD)
(Sueta, 2000), Japan	College women	Students taking a dietitian course	Students taking a dietitian course	NR	Non-RCT I: 54 C: 54	Age: 18–19 Sex: all females
(Talpade and Caddell, 2015), USA	College students	African American students	Enrolled in a research class	NR	B&A I: 40 No control group	Age: 18–26 Sex: 80% females Ethnicity: all AA BMI: 25.71

NR = not reported
B&A = before and after study design
I = intervention
BMI = body mass index;
PP = population pool
PR = participant rate
RCT = randomized controlled trial
C = Control
AA = African American
DRI = dietary reference intake
FFQ = food frequency questionnaire
Non-RCT = Non-randomized controlled trial
BMD = bone mineral density

Table 3. Intervention implementation and adoption.

	Intervention								
Author, year, citation	Mode of contact	Frequency of contact	Setting	Dietary focus	Description	Theoretical construct	Study arms	Personnel	Duration (including follow-up)
(Bohaty et al., 2008), USA	Face-to-face	10 sessions 1 f/u call at 8 wks post-intervention	Community	Calcium and dairy only	45-min slide show presentation followed by group discussion, follow-up phone call and handouts	SCT	I: educational intervention to increase calcium, vitamin D and dairy No control group	Nurses	>8 wks (NR)
(Ehlert, 2010), USA	Face-to-face	4 sessions held every 3 wks	University	Calcium, dairy and other	Four sessions delivered in 1.5 hour segments; face-to-face session followed by discussion, questionnaire	SCT	I: SNAAKS curriculum C: non-nutrition curriculum	Questionnaire reviewed by nutrition and curriculum experts	14 wks
(Gerend and Shepherd, 2013), USA	Face-to-face, handouts	One-off session 1 f/u at 1 mo post-intervention	University	Calcium only	Participants were given 6 mins to read a pamphlet and received handouts to take home	Gain and loss framed messaging	I_1: gain-framed pamphlet I_2: loss-framed pamphlet	NR	~1 mo (NR)
(Ha et al., 2009), USA	Face-to-face	3 times per week	University	Dairy and calcium only	Traditional lecture with interactive activities. Participants met 3 times a week for 50 mins and completed a "Happy Body Log" to encourage behavior changes	NR	I: class-based nutrition intervention No control group	NR	Spring Semester, ~15–16 weeks (NR)
(Jung et al., 2011), Canada	Face-to-face	One-off session, f/u by mail 7 and 24 wks post-intervention	University	Calcium only	45 min seminar followed by second mail-delivered intervention: OSC's 'Speaking of Bones' presentation and two pamphlets	HBM	I: 20 gain-framed messages C: 11 loss-framed messages	Registered dietitian presented the seminar	52 wks
(Koszewski et al., 1990), USA	Face-to-face	One-off session, food intake recorded 4 wks post-intervention	University	Calcium and other	15 min slide-tape presentation with Q&A session at the end	NR	I: slide-presentation C: no presentation	Data collection by trained graduate and undergraduate students	1 mo
(Kwon and Chang, 2000), Korea	Face-to-face	NR	University	Dairy and other	Basic level nutrition course at the university	NR	I: nutrition course No control group	NR	Questionnaire collection for ≥2 wks (NR)
(Martinelli, 2013), Italy	Face-to-face, email	6 sessions over 5 mo	University	Calcium and other	Six sessions with interactive workshops on topics relevant to sports nutrition. Group emails sent for meeting times and other program details	NR	I: nutrition education programme No control group	Qualified sports nutrition professional and performance nutritionist	5 mo
(Peterson et al., 2000), USA	Face-to-face	3 sessions, f/u lab visit at 3 and 6 mo + call reminder before an appointment	University	Calcium only	Three calcium intervention sessions in small groups, explaining osteoporosis, sources of calcium and assessing change in intake	NR	I: behavioral/ nutrition intervention C: no intervention	NR	6 mo
(Peterson et al., 2010), USA	Paper	3 reminder emails sent out to record food intake	University	Dairy and other	A logo "The Right Stuff!" was created at point-of-selection to promote healthy foods. Card showing healthy choices and flyers/ signs distributed in the area.	NR	I: point-of-selection intervention No control group	Content validity by registered dietitians	3 wks
(Poddar et al., 2010), USA	Electronic, online and email	Daily emails for the first 3 wks, then once every wk for the final 2 wks	University	Dairy only	Online course; posted information, behavior checklists and tailored feedback.	SCT	I: web based nutrition education C: no intervention	Doctoral student in nutrition and 3 registered dietitians	5 wks

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Table 3. (Continued).

Author, year, citation	Intervention								
	Mode of contact	Frequency of contact	Setting	Dietary focus	Description	Theoretical construct	Study arms	Personnel	Duration (including follow-up)
(Poddar et al., 2012), USA	Electronic/ online + face-to-face (optional)	Weekly- one module/ per wk. Social event held fortnightly (optional)	University	Dairy only	Online course management system (specifically developed for the study). Participants asked to complete weekly behavior checklists and social events providing nutrition education.	HBM	I: dairy intervention based on SCT C: stress management intervention	A registered dietitian attended social events session to provide education and practical tips on increasing dairy	8 wks
(Shahril and Lua, 2013), Malaysia	Face-to-face, electronic/ text messaging	A total of 13 text messages sent every 5 days	University	Calcium, dairy and other	Multimodal intervention: conventional lectures, brochures and text messaging used	NR	I: multimodal intervention C: no intervention	Nutrition and public health s developed key messages, diet history and data analysis performed by a nutritionist	10 wks
(Sueta and Fukuda, 1995), Japan	Face-to-face	One-off session, food intake recorded 1 wk and 1 yr post-intervention	University	Calcium only	National survey results shown, participants learnt to self-evaluate their eating pattern and set goals, 40 min videotape on why calcium is necessary and taught how to eat enough in their diet (Basic Foods List)	NR	I: calcium education C: no intervention	Basic Foods List developed by dietitians	12 mo
(Sueta, 2000), Japan	Face-to-face	One-off session, food intake recorded 1 wk and 1 yr post-intervention	University	Calcium only	National survey 1991 results shown, participants learnt to self-evaluate their eating pattern and set goals. Education videotape on calcium intake screened and taught how to eat enough calcium in diet (Basic Foods List)	NR	I: calcium education C: no intervention	Video shown developed by a group of dietitians	12 mo
(Talpade and Caddell, 2015), USA	Face-to-face	Weekly sessions held over 2 wks, food intake recorded 3 mo post-intervention	University	Dairy and other	Two 50-min information sessions over two weeks;	Trans-theoretical stages of change model + theory of reasoned action	I: HEALTH intervention No control group	NR	4 mo

F/u = follow-up
SCT = Social Cognitive Theory
I = intervention
Wks = weeks
NR = not reported
MI- motivational interviewing
C = Control
Yrs = years
SNAAKS = Student Nutrition Action, Attitude, Knowledge and Skills
OSC = Osteoporosis Society of Canada
HBM = Health Belief Model
Q&A = Question and answer
GBTL = game based team learning
CDAS = cloud diet assessment system

Table 4. Study results and maintenance.

Author, year, citation	Baseline to post-intervention		Effect size (Cohen's d)	Attrition	Compared drop outs	Follow-up
(Bohaty et al., 2008), USA	Calcium: mg Pre: 961.3 ± 477 Post: 905.0 ± 510 $P = 0.38$ (NS)	Dairy: cups Pre: 0.7278 ± 0.82 Post: 0.8608 ± 0.88 *P*: 0.14 (NS)	NA, no control group	NR	NR	Yes, at wk 2 (phone call) wk 8 (dietary intake).
(Ehlert, 2010), USA	Calcium: Calcium-rich food servings Pre: I: 2.35 ± 1.18 C: 2.42 ± 1.44 Post: I: 2.42 ± 1.45 C: 2.47 ± 1.24 *P*: 0.020	Dairy: frequency/day Pre: I: 0.765 ± 1.84 C: 1.54 ± 4.13 Post: I: 1.51 ± 2.77 C: 0.901 ± 1.66 *P*: 0.800 (NS)	Calcium: -0.037 Dairy: 0.265	Nil	NR	NR
(Gerend and Shepherd, 2013), USA	$B = 0.29$ No further information provided		No control vs. intervention mean and SE/SD for calculation	11% ($n = 15$)	Yes, non-completers were similar to completers for all demographics	Yes, participants returned one month after intervention to provide intake data.
(Ha et al., 2009), USA	Calcium: mg Pre: 813.18 ± 501.48 Post: 858.21 ± 373.11	Total milk: fl.oz Pre: 5.40 ± 9.57 Post: 6.43 ± 11.27 P: 0.433 (NS) Milk: S, NR (females only)	No control vs. intervention mean and SE/SD for calculation	11% ($n = 10$) No control group	NR	NR
(Jung et al., 2011), Canada	Calcium intake (mg): Pre: I: 927 ± 369 C: 891 ± 286 Post: I: 1144 ± 514 C: 813 ± 286 *P*: <0.01		Calcium: 0.787	I: 24% ($n = 16$) C: 29% ($n = 19$)	NR	Yes, at week 8 (mail-delivered intervention), week 25 (mail-delivered intervention) and week 52 (diet assessment).
(Koszewski et al., 1990), USA	Calcium: mg Pre: I: 93 ± 62 C: 116 ± 73 Post: I: 99 ± 71 C: 96 ± 56 *P*> 0.05 (NS)		Calcium: 0.047	NR	NR	NR
(Kwon and Chang, 2000), Korea		Milk and dairy foods: mg Pre: Males: 484.9 ± 232.5 Females: 405.0 ± 233.3 Post: Increase in females, amount, NR Milk & dairy: S, NR (females only)	No control vs. intervention mean and SE/SD for calculation	NR	NR	NR
(Martinelli, 2013), Italy	Calcium: mg Pre: 924.9 ± 365.1 Post: 1112.5 ± 826.2 *P*: 0.510 (NS)		No control vs. intervention mean and SE/SD for calculation	Nil	NR	NR
(Peterson et al., 2000), USA	Dietary calcium intake: Pre: I: 418.17 ± 136.94 C: 470.15 ± 155.81 Post: I: 725.82 ± 334.28 C: 634.16 ± 302.44 Follow-up I: 755.28 ± 305.25 C: 676.96 ± 315.00 *P*: <0.001		Calcium: 0.253	34% ($n = 42$)	Yes, drop-outs had a significantly lower baseline calcium intake compared to those who completed the study	Yes, at 3 and 6 mo for diet assessment.
(Peterson et al., 2010), USA		Cottage cheese: $P = 0.001$ (correlation significant at the $p \leq 0.01$ level) Skim milk P: NR, NS	Calcium:	I: 64% ($n = 184$) No control group	NR	NR
(Poddar et al., 2010), USA		Dairy: total dairy (servings/ day) Pre: I: 1.5 ± 1.16 C: 1.4 ± 1.17 Post: NR P: NR, NS	No control vs. intervention mean and SE/SD for calculation	I: 9% ($n = 13$) C: 7% ($n = 10$)	NR	NR
(Poddar et al., 2012), USA		Dairy: Pre: servings/day I: 1.37 ± 0.95 C: 1.97 ± 0.94 Post: adjusted I: 0.17 ± 7.78 C: -0.13 ± 7.45 P: 0.01	Dairy: 0.039	I: 16% ($n = 17$) C: 14% ($n = 15$)	NR	NR
Shahril and Lua, 2013 (Malaysia)	Calcium: Pre: I: 312.6 ± 100.1 C: 331.4 ± 103.8 Post: I: 376.5 ± 125.4 C: 300.6 ± 116.5 *P*: <0.001	Dairy products: Pre: I: 0.11 ± 0.27 C: 0.05 ± 0.14 Post: I: 0.13 ± 0.27 C: 0.06 ± 0.14 P: 0.005 Milk: Pre: I: 0.08 ± 0.27 C: 0.09 ± 0.28 Post: I: 0.26 ± 0.40 C: 0.09 ± 0.28 *P*: <0.001	Calcium: 0.629 Dairy: 0.332 Milk: 0.498	I: 13% ($n = 27$) C: 5% ($n = 10$)	Higher dropout rate in males (16%) vs. females (8%)	NR

(*Continued on next page*)

Table 4. (Continued).

Author, year, citation	Baseline to post-intervention	Effect size (Cohen's d)	Attrition	Compared drop outs	Follow-up
(Sueta and Fukuda, 1995), Japan	Calcium (mg): Pre: I: 474 C: 494 Post: I: 516 C: 491 *P*: <0.05	No SD or SE reported for calculation	Nil	NA	Yes, at one year to collect dietary intake.
(Sueta, 2000), Japan	Calcium (mg): Pre: I: 474.4 C: 494.2 Post: I: 418.8 C: 409.7 $P > 0.05$ (NS)	No SD or SE reported for calculation	I: 1% ($n = 1$) C: 0	Only one person dropped out	Yes, at one year to collect dietary intake
(Talpade and Caddell, 2015), USA	Inter-item correlation matrix for dairy: 1.000 No further information reported	No SD or SE reported for calculation	33% ($n = 13$)	NR	NR

Pre = prior to receiving intervention
Post = post-intervention
NS = not significant
NA = not applicable
NR = not reported
Wks = weeks
I = intervention
C = control
S = significant
Yrs = years

representation included White or Caucasian ($n = 6$) and a minority included African American, Hispanic or Latino ($n = 3$). A majority of the studies described their target audience as 'college or university students' ($n = 9$), one of which specifically targeted university sports scholar students, and only a few studies targeted the general population ($n = 3$).

Intervention implementation and adaption

Eleven studies focused on improving dairy or calcium as their primary focus and the remaining studies targeted multiple food groups or nutrients. Ten studies promoted calcium, six targeted dairy and four measured both (Bohaty et al., 2008; Ehlert, 2010; Ha et al., 2009; Shahril and Lua, 2013).

As shown in Table 3, the majority of the studies were conducted in a university setting ($n = 15$), with one study conducted in the community (Bohaty et al., 2008). The majority of the studies provided face-to-face delivery of information ($n = 12$). This included lecture style delivery ($n = 5$) (Bohaty et al., 2008; Ha et al., 2009; Jung et al., 2011; Shahril and Lua, 2013), tape or video presentation (Koszewski et al., 1990; Sueta, 2000; Sueta and Fukuda, 1995). Four studies reported including a discussion or interactive activity component (Ehlert, 2010; Ha et al., 2009; Koszewski et al., 1990; Martinelli, 2013). Three studies reported on providing pamphlet, brochures or handouts (Gerend and Shepherd, 2013; Jung et al., 2011; Shahril and Lua, 2013). One study provided a nutrition course in a class setting (Kwon and Chang, 2000), and one study provided education in small groups (Peterson et al., 2000). One study used phone calls as part of their intervention (Bohaty et al., 2008), and one study used text messaging (Shahril and Lua, 2013). Two studies used group emails and one study used mail-delivery to communicate information.

Six studies delivered a single one-off session with some follow-up contact through mail or telephone, which may be considered as lower intensity intervention (Gerend and Shepherd, 2013; Jung et al., 2011; Koszewski et al., 1990; Peterson et al., 2010; Sueta, 2000; Sueta and Fukuda, 1995). Six studies provided multiple sessions over the course of the intervention. Four studies provided contact on a weekly or daily basis which was classed as higher intensity (Ha et al., 2009; Poddar et al., 2012; Poddar et al., 2010; Shahril and Lua, 2013). Psychological theory-based constructs were used in 6 studies and included: Social Cognitive Theory (SCT) (Ehlert, 2010; Poddar et al., 2010), Health Belief Model (HBM) (Jung et al., 2011; Poddar et al., 2012), or a combination of Transtheoretical or Stage of Change and Theory of Reasoned Action (Talpade and Caddell, 2015). Four studies incorporated goal-setting as part of their intervention (Ehlert, 2010; Poddar et al., 2012; Sueta, 2000; Sueta and Fukuda, 1995), one of which provided feedback to participants.

The mean length of intervention was 18.25 ± 18.0 weeks (range: 3 weeks to 1 year). Over half of the studies had a duration of less than six months ($n = 12$). Three studies had duration of one month or less (Gerend and Shepherd, 2013; Koszewski et al., 1990; Peterson et al., 2010). Four studies had a duration of one year or more (Jung et al., 2011; Sueta, 2000; Sueta and Fukuda, 1995). Few studies did not clearly specify the duration; the length of intervention was estimated from the details, where possible.

Study maintenance and institutionalization

Most studies reported on intake at baseline and post-intervention in sufficient detail (Table 4). Calcium intake was measured in mg or calcium-rich servings and dairy amount was reported in servings and frequencies. Of 10 studies with a control group, six studies reported a significant difference between intervention and control group (Ehlert, 2010; Jung et al., 2011; Peterson et al., 2000; Poddar et al., 2012; Shahril and Lua, 2013; Sueta and Fukuda, 1995). For studies without a control group, two studies reported no significant difference before and after intervention (Bohaty et al., 2008; Martinelli, 2013). Three studies reported a significant difference (Ha et al., 2009; Kwon and Chang, 2000; Peterson et al., 2010), two of which were in females only (Ha et al., 2009; Kwon and Chang, 2000).

Attrition was reported in 10 studies; the mean attrition rate was 21.3%, and ranged from 1% to 64%, see Table 4. A majority of the studies did not provide any information comparing drop-out characteristics to completers ($n = 13$). Five studies included follow-up of dietary intake after the intervention (Bohaty et al., 2008; Gerend and Shepherd, 2013; Peterson et al., 2000; Sueta, 2000; Sueta and Fukuda, 1995), while one included continued support via meetings, phone calls or mail-delivered material during the follow-up period (Jung et al., 2011). No studies reported any detail of program sustainability after the intervention research.

Risk of bias

The Cochrane risk of bias assessment is presented in Table S4. A total of eight studies were included for Cochrane assessment, all of which were RCT's. For the overall judgment, four studies rated as unclear, three as high and one was low risk. The majority of the studies rated as unclear for selection bias did not describe the method of randomization or concealment of allocation. A majority of the studies rated as low risk had low or no attrition; only two studies were found to have a high attrition rate (>20%) (Jung et al., 2011; Peterson et al., 2000). For performance and detection bias, most studies were rated as low risk as they provided description on blinding or reported an objective measure of outcome. All studies reported pre-specified outcomes; however, one study was rated as unclear or high as there were large baseline differences between intervention and control group for dairy intake (Ehlert, 2010).

Results for all non-randomized controlled trials and before and after studies assessed using the American Dietetic Association or ADA tool ($n = 8$) are presented in Table S5. Six studies were deemed to have a moderate risk of bias and two as high risk. None of the studies blinded the research team or data collectors for assessment of outcomes. Three studies did not conduct appropriate statistical analysis (Kwon and Chang, 2000; Martinelli, 2013; Talpade and Caddell, 2015). One study did not use valid and reliable instruments to measure outcomes (Talpade and Caddell, 2015).

GRADE quality rating

Study limitations

Of six studies included in the meta-analysis, the majority of the studies rated were as high risk of bias ($n = 3$). Two studies

described the method for providing randomized sequence generation (Poddar et al., 2012; Shahril and Lua, 2013). One study adequately concealed intervention and control groups (Poddar et al., 2012). One study could anticipate allocation as it was explained to participants (Peterson et al., 2000). Three studies described the method of blinding which involved blinding of the principal investigator or research assistants (Ehlert, 2010; Jung et al., 2011; Shahril and Lua, 2013). Three studies performed a completer's analysis (Jung et al., 2011; Poddar et al., 2012; Shahril and Lua, 2013) and one study performed an intention to treat analysis (Peterson et al., 2000). All but one study reported pre-specified outcomes.

Consistency

The effect size for change in calcium intake yielded an I^2 statistic of 75.1% (p value for heterogeneity = 0.003) and I^2 statistic of 53.4% (p value for heterogeneity = 0.092) for change in dairy intake. Both of these results indicate moderate heterogeneity (Fig. 2 and 3).

Directness

There are variations between study design, population and outcome measures which made it difficult to compare between studies. The majority of population included in our study were college students, and only two interventions recruited beyond the university or college setting (Jung et al., 2011; Koszewski et al., 1990).

Precision

Only three studies reported conducting sample power calculations; however, these were mainly based on Bone Mineral Density (BMD) outcomes rather than calcium or dairy intake. One study calculated power to examine bone density (Jung et al., 2011). The sample size of the population included in the GRADE body of evidence yielded 1091 participants (range 78 to 380), which is considered insufficient.

Publication bias

Whilst an extensive search strategy was conducted to minimize the risk of publication bias, this cannot be ruled out as unpublished or negative finding studies may have been missed. Funnel plot and statistical tests of publication bias were not reported as they are not recommended for meta-analyses less than 10 studies due to the inability to detect true symmetry with fewer studies (Higgins, 2011). As shown in Table 5, overall body of evidence was rated as low due to the study limitations, heterogeneity and small sample size in the included studies. Out of six studies included in the meta-analysis, one scored low risk of bias, three as unclear and two were high risk, which indicates serious limitations.

Efficacy of interventions

Of the 16 reviewed studies, 10 studies provided results for calcium and eight studies provided results on dairy intake.

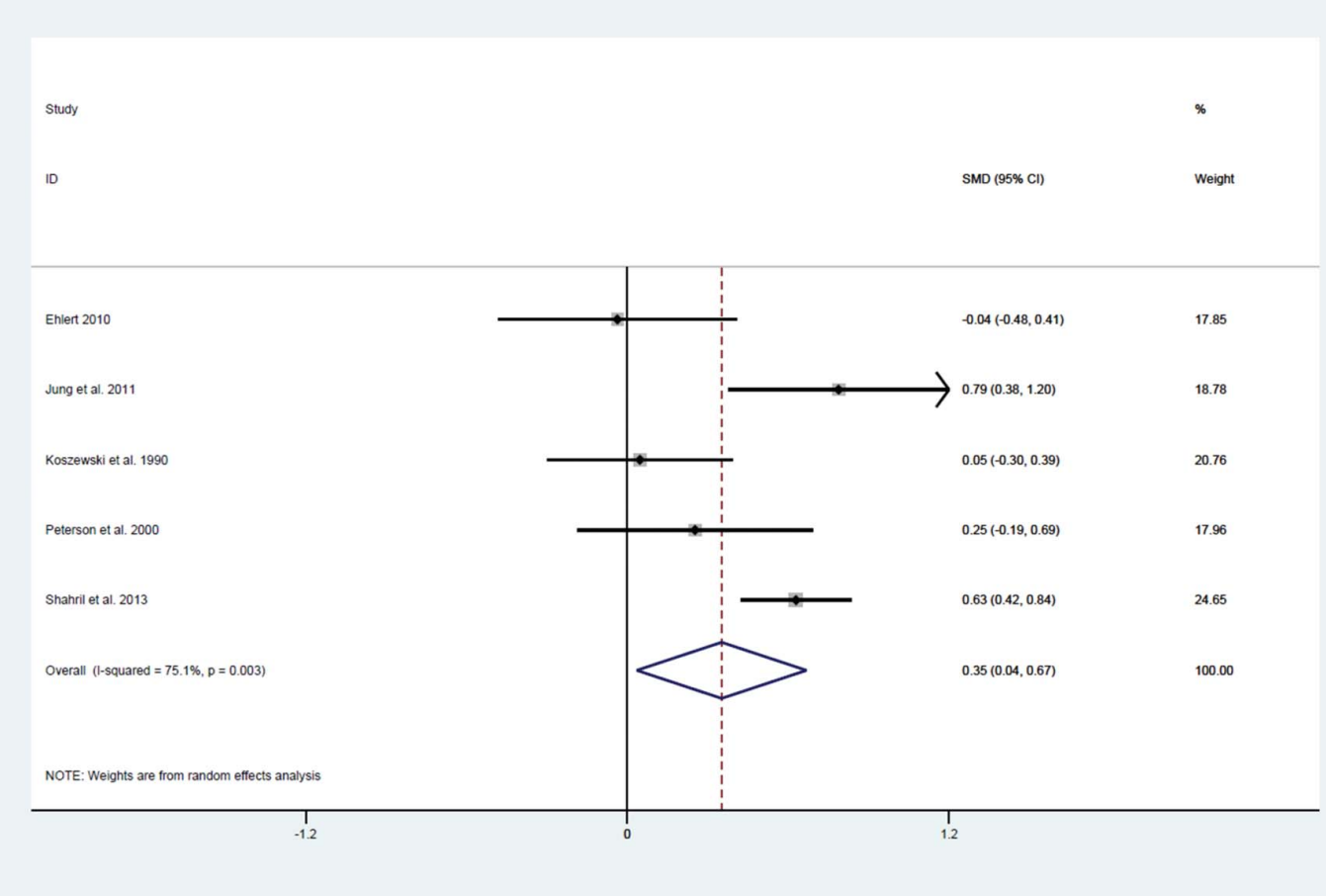

Figure 2. A Forest plot of Cohen *d* effect size for interventions reporting calcium intake.

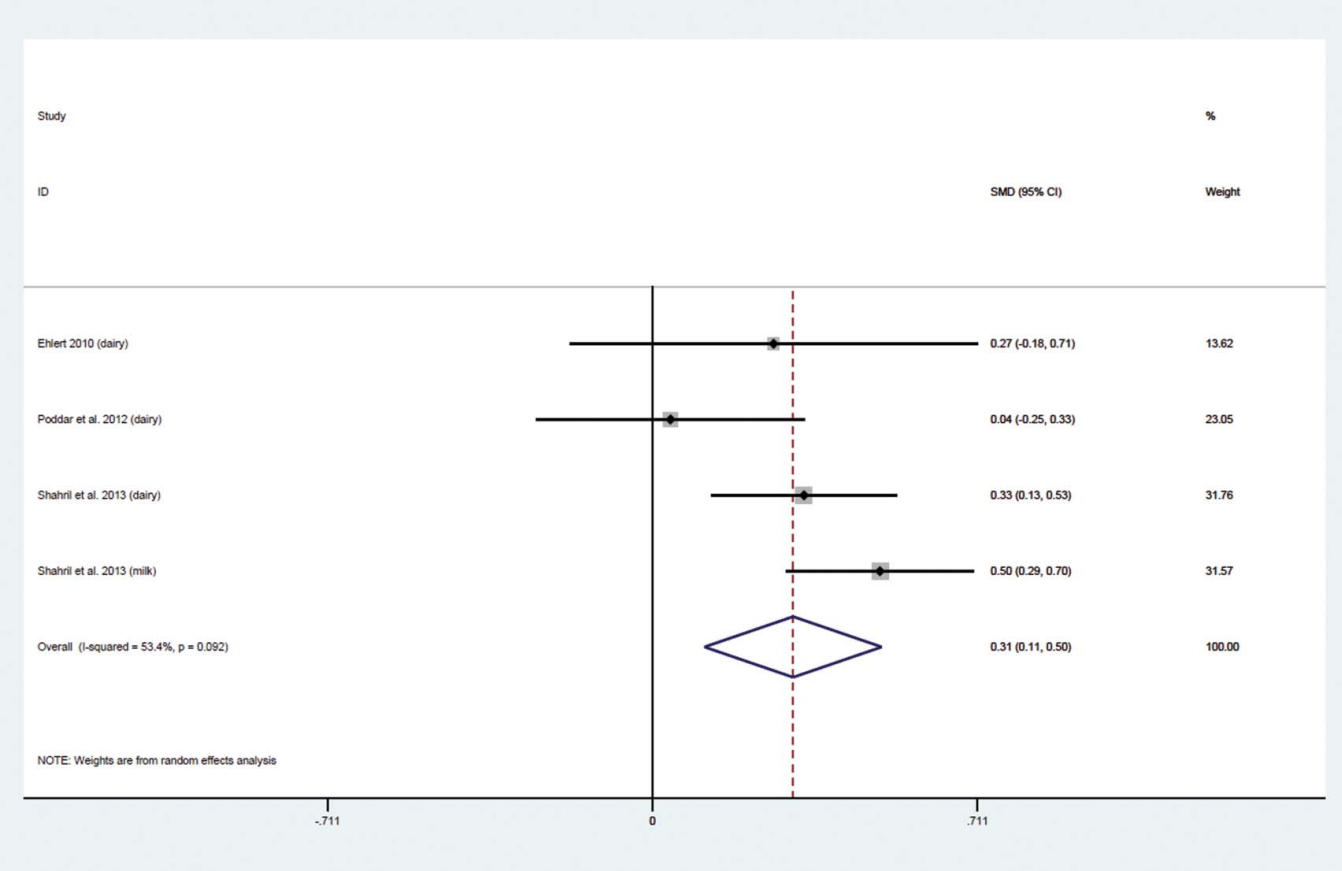

Figure 3. A forest plot of Cohen d effect size for interventions reporting dairy intake.

Four studies included results for both calcium and dairy intake. Studies targeting calcium intake appear to be slightly more successful than dairy intake. For calcium, five studies were included in the meta-analysis; six of which reported positive effects (SMD 0.05–0.79, four were statistically significant). The pooled effect size was 0.35 (95% CI 0.04 to 0.67); all studies contributed similar weighting (ranged from 17.85% to 24.65%).

For dairy, three studies were included in the meta-analysis; all of which reported positive effects (SMD 0.04–0.50, two were statistically significant). The pooled effect size was 0.31 (95% CI 0.11 to 0.50). Contributing weighting of studies ranged from 13.62 to 31.76%).

Table 5. Overall assessment of quality in 6 studies (1091 participants) of promotion of calcium or dairy intake using Grading of Recommendations Assessment, Development and Evaluation (GRADE) system (Atkins et al., 2004).

Category	Rating with reasoning
Limitations	−2 quality level due to serious limitations
Consistency	−1 quality level due to high heterogeneity score
Directness	No subtraction of levels, as the population, outcomes and study design are direct
Precision	−1 quality level due to small sample size
Publication bias	No subtraction of levels, not reported as it is not possible to detect true symmetry when there are less than 10 studies
Overall quality	Low; our confidence in the effect estimate is limited

Quality and validity of dietary assessment tools

As shown in Table 6, over half of the studies scored as acceptable/ reasonable ($n = 9$). Five studies were rated as poor and two studies rated good. The mean score was 2.5, and ranged from 1 to 4.

Of the reviewed studies, the most common method of assessing intake was food record ($n = 8$) and three studies used a dietary recall. Five used tools that were specific to the study such as questionnaires, FFQs (Food Frequency Questionnaire) and capturing photos of meals. Three studies used a FFQ, one of which had been validated previously in a similar population (Gerend and Shepherd, 2013), and one conducted a test-retest of the instrument (Peterson et al., 2010). A majority of the studies did not acknowledge appropriate validation studies in relation to the use of their tool; (Hertzler and Frary, 1994; Ilich et al., 1998; Thompson and Byers, 1994) and only three studies provided details of a validation study in sufficient detail (Gerend and Shepherd, 2013; Jung et al., 2011; Peterson et al., 2000).

Discussion

To our knowledge, this is the first systematic review of interventions of calcium or dairy intake among young adults. Our findings suggest that calcium or dairy interventions may have a small effect on increasing intake, as indicated by the

Table 6. Dietary quality of tools used to measure calcium and dairy intake.

Study	Method	Validated tool	Dietary score: calculated using ACAORN criteria (Burrows et al., 2012)	
(Bohaty et al., 2008)	Dietary record	No	1.5	Poor
(Ehlert, 2010)	SNAAKS questionnaire	No	3	Acceptable/ reasonable
(Gerend and Shepherd, 2013)	55-item FFQ	Yes (Ilich et al., 1998)	4.5	Good
(Ha et al., 2009)	3-day food record	No	2.75	Acceptable/ reasonable
(Jung et al., 2011)	3-day food record	Yes (Thompson and Byers, 1994)	2	Poor
(Koszewski et al., 1990)	Previous 24-hour food intake	No	1.5	Poor
(Kwon and Chang, 2000)	3-day recall	No	2	Poor
(Martinelli, 2013)	7-day food record	No	2.5	Acceptable/ reasonable
(Peterson et al., 2000)	Hertzler and Frary's rapid assessment questionnaire	Yes (Hertzler and Frary, 1994)	4	Good
(Peterson et al., 2010)	FFQ intake	No	2.25	Acceptable/ reasonable
(Poddar et al., 2010)	7-day food record	No	3.25	Acceptable/ reasonable
(Poddar et al., 2012)	7-day food record	No	2.75	Acceptable/ reasonable
(Shahril and Lua, 2013)	Dietary recall	No	3.25	Acceptable/ reasonable
(Sueta and Fukuda, 1995)	3-day weighted food record	No	2.25	Acceptable/ reasonable
(Sueta, 2000)	3-day weighted food record	No	2.25	Acceptable/ reasonable
(Talpade and Caddell, 2015)	Capturing meal before and after photo	No	1	Poor

meta-analyses. However, findings must be interpreted with caution, due to the presence of heterogeneity and poor quality of the intervention studies.

Education was reported as the most widely used technique to change behavior. It was previously suggested in the literature that knowledge of calcium was related to intake of dairy foods (Nicklas, 2003). While knowledge is important, it is apparent that knowledge on its own is not sufficient for a behavior change to take place (Brug et al., 2005; Jepson et al., 2010). Participants must be taught the 'how to' aspect of behavior change (Worsley, 2002). Research has established the importance of incorporating a behavior change theory in the intervention (Brug et al., 2005). Half of the studies included a theoretical construct or a behavior change technique in their intervention, but of these only four of seven had positive outcomes. Self-efficacy is often thought to be the best predictor of engagement in a particular behavior (Hackman and Knowlden, 2014), but it is reported that there are two phases of self-efficacy motivational and volitional in healthy eating and both need to be high for behavior change (Ochsner et al., 2013). This may be why only three of five studies addressing self-efficacy were successful. A meta-regression examining successful behavior change techniques for adopting healthy eating and physical activity in adults revealed that self-monitoring combined with at least one other technique from control theory such as goal-setting and feedback was more effective (Michie et al., 2009). Four studies used goal-setting and two of these resulted in positive behavior changes, one of which also used self-monitoring.

Among the studies that improved dairy or calcium intake, only small changes were observed. Several studies reported the increase being significant but still inadequate compared to dietary guidelines. The benefits resulting from behavioral modification to improve calcium intake may only be evident over time, however the long term effectiveness of the interventions in the current review cannot be determined since only seven studies included a follow-up. They will only reap the benefits if the behavior modifications are sustained and a longer follow-up is required to determine this. It is necessary to address any barriers, as well as beliefs and myths concerning dairy foods consumption. Future studies may benefit from addressing barriers to dairy consumption in order to address long-term behavior change, as stated in a recent review (Hendrie et al., 2013).

From our assessment of dietary tools, it is evident that some uncertainty remains in the quality of the tools used. In order to assess shortfalls in a population, an accurate measurement is required. An earlier review by Magarey et al emphasized the need to develop better quality tools to assess calcium and dairy foods intake (Magarey et al., 2014); our findings from this review are in agreement. The studies included in this review are of uncertain quality as a majority of the papers did not conduct blinding of investigators and participants or ensure random allocations or concealment or blinding of assessors. However, two studies rated scored as high quality, both of which were effective.

The degree to which the interventions can be translated to the broader young population is poor, as a majority of our studies recruited from a university or college setting. Most of the studies were conducted in western countries and used convenience sampling. Even though the latest statistics show a greater proportion of young adults entering tertiary education (OECD, 2016), young people in lower socioeconomic status remain underrepresented (Centre for the Study of Higher Education, 2008). This gap could be addressed by recruiting outside the tertiary sector in the community at large.

None of our studies provided information of sustainability or costs; therefore, the external validity remains unclear. Numerous systematic studies have emphasized the lack of external validity in the field of public health research (Blackman et al., 2013; Klesges et al., 2008; Laws et al., 2012; Nour et al., 2016; Partridge et al., 2015). In order to upscale interventions and translate into the wider community, studies need to report on external validity components, particularly program sustainability and cost-effectiveness.

Interventions which were of higher intensity (i.e. provided weekly or daily contact) did not perform any better compared to interventions that were of low intensity (only one point of contact) or moderate intensity. This is consistent with a recent review (Racey et al., 2016), which included children from 9 to 18 years in a school setting. Face-to-face contact was the most

widely used method for delivery of the interventions, however, with increasing use of technology; a small number of interventions incorporated an electronic component. Recent reviews on e-health or m-health interventions for other dietary behaviors have shown promising results (Free et al., 2013; Nour et al., 2016). A recent review targeting dairy food intake in adolescents found that interventions were successful without providing an individual contact (Marquez et al., 2015). This is an important consideration as it means group delivery of an intervention may be sufficient when targeting this age group, resulting in lower costs. Earlier reviews have pointed out the lack of electronic interventions in this field of research (Marquez et al., 2015; Ryan et al., 2013). There is the potential to explore the use of electronic technologies in interventions to improve intake of dairy products, as they are a convenient and possibly cost-effective alternative to traditional modes (Steinhubl et al., 2015).

Three studies in our review included a form of electronic technology, two of which were successful and incorporated face-to-face contact, which indicated that some human contact may be important. It may be worth focusing on a discrete nutritional behavior rather than trying to change numerous behaviors (Hendrie et al., 2013; Jung et al., 2016; Sweet and Fortier, 2010).Targeting one nutrition behavior may be more manageable for the participants as they are likely to view it as seemingly minor and manageable compared to a global change in diet (Jung et al., 2016)

Future studies could consider online-technology based interventions because they can double the number of users as opposed to an average public health campaign (10% vs. 5% respectively) (Cugelman, 2013). With the rise of the internet as a source of nutritional and medical information and high ownership of smartphone in young adults, these may be appropriate channels to deliver health promotion (Kite et al., 2016; Pollard et al., 2015). Furthermore, smartphones are becoming very popular, young adults having the highest smartphone ownership and a recent US survey has revealed that 85% young adults are smartphone user and almost three-quarters have used their smartphone to look up health information (Pew Research Center, 2015). There have already been a number of successful interventions addressing other nutritional behaviors using this media to promote nutritional behavior (Allman-Farinelli et al., 2016; Coughlin et al., 2015; Nour et al., 2017; Olson, 2016).

This review has several strengths which include a comprehensive search strategy, adherence to PRISMA protocol for selection of studies (Moher et al., 2009), and a meta-analysis for dairy foods and calcium intake. In addition, two reviewers conducted a risk of bias and GRADE assessment to assess the overall body of evidence. The limitations of the included studies are the dietary tools used to measure dietary intake and overall poor quality of studies. The limitations of the search strategy include filtering studies that were only published in English and those indexed in major databases. While attempts were made to search grey literature, the possibility of publication bias cannot be ruled out. Finally, the considerable differences in the intensity of the interventions made it difficult to make direct comparisons between the studies.

In conclusion, our review revealed some evidence demonstrating that calcium and dairy interventions are effective; however, poor quality of studies and moderate heterogeneity remain a limitation. Future interventions could include a form of electronic technology, self-monitoring, goal-setting and social support for increasing intake. Greater rigor is needed in terms of reporting external validity components and improving quality of interventions in order to confidently determine their effectiveness and cost-effectiveness for dissemination to the population-at-large. The findings of this review may be used to inform the development of future interventions targeting young adults for increased calcium and dairy intake to optimal levels.

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Chapter Five

The barriers and enablers to achieving adequate calcium intake in young adults: a qualitative study using focus groups

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5.1 Publication details

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5.2 Author contribution

I Anika Rouf (the candidate) and MA-F developed the research question. Focus groups were structured by AR and SC. AR and SC contributed to conducting and recording of focus group sessions. Data analysis was completed by SC and checked by AR. Author SC and AR were responsible for writing the first draft of the manuscript. MA-F guided the study and provided critical comment to finalise the manuscript. All authors have provided input to the content of the final manuscript.

5.3 Introduction to the chapter

As detailed in Chapter Four, previous interventions were mostly paper-based and were not very effective in improving calcium or dairy intake. Therefore, it is important to explore the contributory factors for our specific target population before developing an intervention. Focus groups are a valuable instrument in providing valuable information in developing an effective intervention. This chapter will explore the enablers and barriers of young adults in relation to calcium intake. This chapter aims to understand the psychosocial determinants (attitudes, knowledge and perceptions) of young adults in regards to calcium intake. Although other countries have previously addressed motivators and barriers to calcium intake, no study has been conducted on Australian young adults.

5.4 Abstract

Background: Despite the established benefits of calcium consumption, many young Australians are not meeting the recommendations for calcium intake. This is concerning because an adequate calcium consumption is important throughout young adulthood to reach peak bone mass and for the prevention of osteoporosis. Therefore, the present study aimed to explore the barriers and enablers to consuming calcium-rich foods with young adults.

Methods: Using a semi-structured question guide, five focus group discussions were conducted with 39 participants [mean (SD) age 22.5 (1.8) years]. Participants were mostly females (n = 29) and enrolled in tertiary education (n = 31). A deductive approach was used to group common ideas into themes. The findings from the focus groups were analysed using the COM-B framework, which examines the interactions between three key components (i.e. capability, opportunity and motivation).

Results: On examining the young adults' capability to consume a diet adequate in calcium, it was found that young adults had limited knowledge of sources, prevention of disease and recommended amounts. Some participants voiced physical barriers to consumption (lactose intolerance). Opportunity was reported as a physical (availability of calcium-rich foods), financial and social opportunity. Some participants reported motivation to include dairy as a result of the habit becoming engrained during their childhood under parental influence (automatic motivation), whereas others reflected on a lack of awareness relating to inadequacy and health consequences (reflective motivation).

Conclusions: Although social media was seen to be an acceptable mode of intervention, concerns were raised about the source and credibility of the information. The findings may inform the development of future interventions targeting eating habits of young adults.

5.5 Introduction

Calcium requirements during adolescence into young adulthood are of significant importance (1). It has been demonstrated that the calcium intake during growth may influence peak bone mass and that a deficiency in calcium intake can lead to low bone density or osteoporosis later in life (2). Around 99% of the body's calcium is found within the bones to provide structure and strength (3). It is an important nutrient required during growth to ensure the development and maintenance of the skeleton (4). Calcium is also important with respect to blood pressure regulation (5), cancer protection (6–8), obesity prevention (9,10) and diabetes prevention (11,12). Despite the many benefits of calcium consumption, most young Australians are not meeting the recommendations for calcium intake (13). The latest National Nutrition and Physical Activity Survey (NNPAS) 2011–2012 states that approximately 44% of males and 71% of females fail to meet the estimated average requirement for calcium (13).

These numbers are concerning and indicate the need to determine an effective way of increasing calcium consumption in young adults.

A number of studies have looked at common barriers to eating calcium-containing foods, although there has been limited research conducted exclusively in young adults. In the general population, the reported barriers included a lack of knowledge regarding nondairy calcium-rich foods (14); the belief that all dairy foods are high in calories, cholesterol (14–16) and fat (17); the cost of milk compared to other beverages (17); and perceived versus real lactose intolerance (18). Studies have also examined common enablers and motivators to consume calcium-containing foods, which included association with positive outcomes such as stronger hair and nails and more energy; awareness of peak bone mass; and prevention of osteoporosis (19,20). However, many of these studies have focused exclusively on the views and attitudes towards dairy products and have not extended this to all calcium-rich foods. This concept is original and emphasises the need and importance of the present study. In addition, only one Canadian study (20) has explored the perception of calcium in young men and women and so the present study conducted in Australian 18–25-year old adults is novel.

To develop ways and strategies that help increase calcium consumption, it is important to gain an insight into eating behaviours, beliefs, attitudes and knowledge so that an effective intervention can be developed. The current research also examines opinions about the use of social media for an intervention aiming to improve calcium consumption. Over the last decade, the use of the Internet and digital media has increased significantly, allowing an extra avenue for health education to be delivered. The World Health Organisation defines eHealth as the use of the modern information and communication technologies for health (21) and mHealth is a sub-category that refers to the use of mobile devices in a medical or public

health setting (22). Internet and smartphone-delivered public health interventions have recently emerged and gained momentum (23), leading to an opportunity to use social media to address issues such as calcium inadequacy. The current research explores the barriers and enablers to the calcium consumption in Australian young adults (18–25 years old) and informs the development of a new social media intervention in young adults if this delivery channel is acceptable to the target group. An age range of 18–25 years was used in the present study because this represents the period in adulthood where calcium intake has the greatest impact on peak bone mass development (24,25).

5.6 Methods

The materials and methods used for the focus groups were approved by the Human Research Ethics Committee at the University (HREC). The ethics approval number is 2017/218.

5.6.1 Recruitment

Men and women aged between 18–25 years were eligible to participate. Participants were recruited via Facebook, tab-flyers and active face-to-face recruitment. A recruitment flyer was posted on Facebook and sent to existing friends, connections and public groups within networks of the researchers conducting the study. The flyer was shared to enable a greater reach of participants. Tab-flyers were posted on public notice boards that were widely viewed, such as in food courts and kitchens, as well as in public places around university campus, such as bathrooms. Participants were actively recruited via announcements at the start of lectures and face-to-face active recruitment on campus.

People interested in the study e-mailed the researchers and a member of the research team then screened individuals for eligibility. Participants were given an information sheet to

provide them with more information about the study and what was required of them. If they remained interested, they were booked into a focus group session. Participants were offered a $10 store voucher as a reimbursement for their time. The amount was not specified in the recruitment material. Participants were excluded if they had undertaken or were currently undertaking a nutrition-related subject or degree. Participants were also excluded if they were regularly consuming calcium supplements because of their demonstrated knowledge of calcium and the effects it has on health (26).

5.6.2 Procedures

Participants were allocated to a focus group session at a time convenient to them. Five focus groups were conducted over two consecutive weeks in rooms on a university campus. This was to ensure a range of participant responses, as well as for satisfactory theoretical saturation to be reached (27). Data saturation was defined as collection of data until there were fewer surprises with the responses and no new themes emerged (28). The focus groups were led by a female facilitator (AR, dietitian and PhD researcher). A moderator (SC, student dietitian) was present to record group dynamics and nonverbal communication, as well as to assist with time-keeping. Focus groups were audiotaped to enable systematic analysis of the discussions. The size of the groups ranged from six to nine participants and each ran for approximately 1 h in duration.

Upon arrival, participants provided their written informed consent to the audiotaping of the focus group and completed a short questionnaire. Data collected included demographics (age, gender, education level), whether they followed a specific diet (e.g. vegetarian, sugar-free, calorie-restricted) or had lactose intolerance, and whether they considered it important to include calcium, naming calcium-containing foods and rating the importance of eating healthily. After completion of the focus group, an additional questionnaire was administered

to determine whether their views had changed in regard to knowledge gain or motivation to eat foods rich in calcium, as well as to gain an insight into their personal barriers and determine their preference for a social media platform.

The focus group structure followed the methods suggested by Krueger and Casey (27) to ensure good discussion and exploration of themes. The focus group discussion was semi-structured to ensure consistency with respect to the information given to all the groups and allowed for some level of flexibility in the discussion by participants (29). The discussion focused on the participant's general knowledge of calcium, how they viewed their personal intake of calcium and calcium-containing foods in terms of adequacy and inadequacy and the factors affecting calcium intake, as well as the personal enablers and barriers to consuming particular foods containing calcium and whether obtaining sufficient calcium is actually a concern of people their age (Table 5.1). Finally, participants were asked for suggestions regarding effective ways to convey the importance of consuming calcium-containing foods in the diet and whether they considered the use of social media for an intervention would be acceptable and appropriate.

Table 5.1 Line of questioning developed and used in focus groups to gather information on the barriers and enablers of consuming calcium-containing foods.

Focus Group Questions	
General Calcium Knowledge	What do you know about calcium? Do you know how much you should be having every day? Why it is good for our health? What comes to mind when you think of sources of calcium in the diet? Where do you think these are found? What do you think is the best source of calcium in the diet? What is your understanding of calcium-rich foods? How much is one serving? Do you think getting enough calcium is a concern of people in your age group? Is getting enough calcium a concern for you?
Information about personal calcium intake/ factors affecting calcium intake	What are the main calcium containing products you consume? What do members in your family usually consume? What are the beverages you drink throughout the day? Thinking about the calcium containing products that you do consume, why do you consume these particular products? What are some foods that you know contain calcium but that you do not consume? Why do you not consume them? Is the fat content in dairy products a concern for you? Does the cost of calcium-rich food influence your ability to meet your calcium goal? Do you think eating foods rich in calcium is time consuming/ too expensive/ not affordable?
Improving calcium intake	Are there any strategies that you use to help make sure you are getting enough calcium in your diet? What strategies would be helpful to motivate you to consume more calcium-rich foods? Do you think social media could be incorporated into reminding people your age about the importance of consuming calcium or even used as a reminder? What would you consider to be the most effective way to convey messages about the importance of getting enough calcium in your diet to people in your age group?

5.6.3 Data collection and analysis

By the end of the fifth focus group, the researchers came to the conclusion that saturation in themes had been reached and no new ideas were being generated. Data were analysed following the completion of all the focus groups and each audiotape recording was transcribed. Transcripts were checked for quality control and then imported into NVIVO, version 11.0.0317 (QSR International Pty Ltd, Melbourne, VIC, Australia), comprising

software that is commonly used for the analysis of qualitative research. Analyses were guided by Knodel (30) and Hsieh & Shannon (31), which involved determining patterns in ideas and their frequency.

An initial set of codes were developed corresponding to the categories of questions (i.e. general calcium knowledge, factors affecting intake and strategies to improve calcium intake). All participant responses were then grouped and coded for frequency. Codes were also identified from previous research conducted on this topic that addressed common themes such as cost and knowledge (20,32). A deductive reasoning approach was used that involved moving from general to specific information. The themes were then grouped using the COM-B framework which examines the interactions between three key components (i.e. capability, opportunity and motivation), and is a well-known method for analysing target behaviours and developing behaviour change interventions (33). Michie et al. proposed that an individual requires capability (C), opportunity (O) and motivation (M) to perform a certain behaviour (B) (34,35). The COM-B model, which aims to guide the understanding of behaviour, proposes that an individual must be physically and psychologically capable; have the social and physical opportunity; and have the motivation as an automatic process or as a result of reflective processes (intention or choice) to engage in behaviour change. Once the analyses were completed, the research team met to discuss results and determine the final codes. The coding was crosschecked by another researcher to ensure accuracy. Differences in responses between females and males were also explored using NVIVO. The synthesis of the findings presents the general themes and supportive quotes from the focus groups identified by P (participant) and FG (focus group) number.

5.7 Results

Participants included men and women from a large urban university, as well as those who worked full-time. In total, 39 young adults (10 men) participated in five focus groups [mean (SD) 22.5 (1.8) years]. The majority were female and completing tertiary education. Demographic information is summarised in Table 5.2. The majority of participants did not follow a specific health regime (n = 28). Some diets that were mentioned by 11 participants included the 5: 2 diet, monitoring calorie intake, weight loss, limited dairy intake, gluten free, limited sugar, vegetarian and pescetarian. The responses to the pre- and post-focus group questionnaire are summarised in Table 5.3. A majority of young adults were aware of dairy as a good source of calcium and related the importance of calcium to bones, health or strength. The most reported knowledge learnt from the focus groups comprised new sources of calcium or calcium content of foods. A lack of time was also stated as the main barrier to eating foods rich in calcium.

Enablers and barriers to eating sufficient calcium-rich foods identified five themes from participant responses. First, psychological capability was dependent on general calcium knowledge; physical opportunity and automatic motivation determined the enablers, whereas psychological capability, physical capability and reflective motivation described the barriers. Finally, social opportunity and reflective motivation supported ways of improving calcium intake, and social opportunity also highlighted the influence of social media.

Table 5.2 Focus group participant demographic information (n=39)

Characteristics	Group (n = 39)
Age, years, M ± SD	22.5 ± 1.8
Gender, n	
Male	10
Female	29
Highest level of education, n	
Year 10	0
Year 12	5
Tertiary	31
Other	3

Table 5.3 Summary of responses from pre and post questionnaire

Pre focus group questionnaire	
Question	**Response**
Do you currently follow any specific diet or health regime that influences your food choices? For example, weight loss program, paleo, vegetarian, vegan, sugar-free). If yes, please explain.	Yes (n= 11) No (n= 28)
Do you have diagnosed lactose intolerance?	Yes (n= 2) No (n=37)
Do you think calcium is an important nutrient to include in your diet?	Yes (n=39) No (n=0)
If yes, why do you think calcium is important?	Mentioned in their response: 'bone strength' (n=13) 'bone density' or 'osteoporosis' (n=3) 'cellular process' or a physiological function (n=6) 'bones' or 'maintenance' (n=9) 'bone health (n=6) 'bone development' (n=5) 'teeth' (n=5) Other (n=4)
What types of food do you think are rich in calcium?	Mentioned in their response: 'dairy' (n=13) 'milk and cheese' (n=9) 'milk, cheese and yoghurt' (n=10) 'leafy greens' or 'some vegetables' (n=5) 'almonds' or 'nuts' (n=3) 'fish' or 'seafood' (n= 5) 'tofu' (n= 2) a specific vegetable (i.e. spinach, kale) (n=2)
How important is eating healthy to you?	Very important (n=14) Important (n=19) Somewhat important, but I have other priorities (n=6)

Post focus group questionnaire	
Do you think you have gained any new information from this focus group?	Yes (n=38) No (n= 1)
If yes, please tell us what you have learnt.	Mentioned in their response: New sources of calcium or calcium content of foods (n =27) RDI or amount of calcium required (n = 13) Statistics on inadequacy or deficiency (n= 5) Importance of calcium (n = 5) Realised not getting enough (n= 4)
Do you think today's focus group has increased your motivation to eat foods rich in calcium?	Yes (n= 36) No (n= 3)
From your personal experience, what makes it challenging for you to eat foods rich in calcium? Tick more than one option, if relevant.	I don't have the time to plan what I eat (n= 21) I don't see calcium as being so important to include in my diet (n= 10) I don't know where calcium-rich sources are found (n=7) I don't think it's worth the cost. I think calcium rich foods are costly (n=7) Other (n=15) Nothing (n=3)
Based on your own opinion, what social media platform would you prefer to see this on?	Facebook (n= 32) Instagram (n= 21) Twitter (n= 1) Other (n= 8)

5.7.1 Capability

Psychological

When considering psychological capability, the majority of the participants reported a lack of knowledge about calcium. Four themes were identified, which included bone health, physiological processes requiring calcium, recommended intakes and food sources of calcium. A majority of participants associated calcium with bone health and strength. However, only some respondents were able to identify the role of calcium in osteoporosis and bone health.

'Good for bone strength' (female, P5 FG1)

'Good for preventing osteoporosis' (male, P21 FG3)

‘I think consumption of calcium in adolescence determines your bone health later in life’ (female, P27 FG4)

Some respondents were aware of the role of calcium for their physiological processes with comments.

‘Essential in many cellular processes’ (female, P7 FG1)

‘Important for physiological function, such as cell signalling’ (female, P10 FG2)

‘Essential for heart and blood supply system work’ (female, P17 FG3)

A few female participants demonstrated knowledge in relation to menopause.

‘Women stop absorbing calcium at a certain age, it slows down’ (female, P19 FG3)

‘During menopause, more leaches out of your bones’ (female, P18 FG3)

Some participants could indicate the recommended calcium intake in milligrams, yet they were unable to translate this to food amounts. A few young adults openly admitted not knowing the recommendations for their age group.

‘I don’t really know what the recommended is or what you are meant to have’ (female, P19 FG3)

With regard to sources of calcium, most participants identified milk and dairy products as the main source of calcium. A smaller number identified leafy green vegetables and fish as a source of calcium. Meat was incorrectly identified as being high in calcium. Females provided a broader range of sources of calcium, which included soy, tofu and beans, compared to males. When prompted further, the source of the knowledge was reported as general learning, media such as television advertisements and the influence of their parents.

‘I instantly think of dairy products like cheese, yoghurt’ (female, P8 FG3)

‘I think some vegetables; I don’t know which ones specifically’ (female, P13 FG2)

When asked about strategies that may improve intake, respondents suggested that an intervention may be appropriate for raising awareness of other sources of calcium and how much calcium they contained. Participants also raised the desire for calcium requirements to be presented in a form that is relatable to common foods and portion sizes.

'I don't know what 1000 mg looks like, I would prefer saying like have a glass of week to get your amount' (female, P21 FG3)

Physical

The participants raised the issue of lactose intolerance and recognised friends placed themselves on dairy-free diets without seeking any medical advice. Some female participants said dairy products made them feel 'really full' or 'not too great'.

'More of a craze to go dairy-free than have dairy' (female, P5 FG1)

5.7.2 Opportunity

Physical

Cost and convenience were seen to be important motivators to consume dairy products. Participants indicated that cost was important to them and the price of milk was an important factor. Participants reported the relatively cheap price of milk in Australia as their top reason for purchase.

'I think dairy which is the main thing we think of is pretty affordable, milk is very affordable' (female, P13 FG2)

Respondents appreciated the convenience of some dairy products and reported enjoying this aspect.

'It's not time consuming to put milk on your cereal' (male, P3 FG1)

'It's convenient to grab a tub of yoghurt to leave the house or something' (male, P8 FG1)

Although participants were unconcerned about the cost of milk saying it was inexpensive, they viewed the waste as a concern because containers were large and limited shelf life. The main concern arose from size of the container for milk or yoghurt; however, it was only by young adults who lived out of home or cooked for themselves.

'That's money wasted if I don't finish it' (female, P9 FG2)

Some other sources of calcium were viewed as too expensive, such as cheese, almonds and fish. Participants also acknowledged the higher cost of lactose-free products and stated it would be more difficult to reach calcium recommendations for those with intolerance.

'If you look at the lactose-free alternatives, I would feel like they might be more expensive, if you were lactose intolerance then it might be harder to meet calcium goals' (female, P18 FG3).

Social

Participants in our focus groups did not report any current social opportunities in relation to their calcium intake. However, respondents suggested the use of public figures or celebrities and cross-platform campaigns to create awareness of the need for calcium consumption. Although respondents considered the latter to be an appropriate medium to seek the attention of young adults on social media, concerns were raised about the source and credibility of the information and its appeal to young adults. Subjects raised the issue of trust when it came to social media as a result of the amount of information on this platform. The participants reiterated the need for a 'trustworthy source' if information of calcium were to be put onto social media. Participants were concerned about the location and access of accurate information on social media, as illustrated by the following quotes.

'I think it's difficult with social media, you are not going to follow calcium or dietitian unless you are already conscious about or aware of that, in order to get a wide audience, something

where people who aren't really thinking about it is your target, people who aren't exposed to it or conscious of it' (female, P18, FG3)

'I auto tune some of it out because it is hard to trust, I like The Conversation website, scholarly articles which are done in a more understandable way, if this could be shared through avenues like Facebook more often, something that I trust, sharing it through trustworthy platforms' (female, P4, FG1)

Furthermore, participants said that information would have to be appearing in a catchy manner as they would otherwise 'just scroll past it', as stated by a participant (male, P13 FG2). Participants suggested memes, funny videos or fun quizzes about calcium consumption as possible ways to obtain the attention of young adults on social media. Some participants were able to recall past media campaigns that heavily relied on celebrities, such as the 'Got Milk' advertising campaign from the USA. Respondents suggested ideas similar to 'Milk Moustache' to gain appeal among young adults and investing on social media ads. Creating a short summary of research articles was also raised as a method to create awareness.

'There used to be the "Got Milk" in America with celebrities, maybe if you used Instagram or other forms of social media with endorsements' (female, P18, FG3); 'maybe put an ad before YouTube videos, compulsory ads' (P21, FG3)

'Maybe Facebook ad, they pop up and can lead to something else, maybe to calculate how much you are eating' (P19, FG3)

5.7.3 Motivation

Automatic

Taste was highlighted by participants as the top reason for consuming calcium-containing products, particularly dairy foods. Another stated that it was a good source of energy. 'I have

Greek yoghurt for breakfast because it's delicious and I know it's good for me' (female, P39 FG5)

'I think, for me, the energy I get from it' (female, P26, FG4)

Participants indicated the family environment as having an effect on their calcium intake and knowledge as a result of their mothers positively influencing their dairy consumption in childhood.

'I think with calcium it was more my mum forcing me to have milk, I still have it now' (male, P30 FG4)

'When I was little, my mum told me it would make me grow' (female, P25 FG4)

Cultural practices were referred as another reason for consumption of milk. A few respondents stated that dairy products were popular and traditional in their culture.

'In our culture, it is just engrained to have a glass of milk for strong healthy bones' (male, P8 FG1)

'I feel like it would be more habit or what you are used to, I have always grown up drinking milk or milk in the tea, difficult if you are on your own if you aren't thinking about for you to put calcium-rich foods in your diet' (female, P18, FG2)

Reflective

Although fat content was never raised by participants as a barrier to consuming calcium-containing products, participants voiced their opinions, once probed. Some participants expressed concern about the fat content of cheese, whereas many others had no concern about the fat content of dairy products at all.

'I am conscious of eating it, knowing that cheese has a higher amount of fat' (male, P8 FG1)

Comments made on fat content were compared between genders. Female participants were aware of the fat content of dairy foods, compared to males. Although some females stated their concerns, the majority of them mentioned switching to low fat or skim milk and did not appear to alter their overall intake of milk.

'I don't look at the fine print of the label, but if the front says lite then I will buy that' (female, P38 FG5)

'When I am at home, I drink lite milk, when I am out, I drink skim' (female, P18 FG3)

Participants who reported themselves as being lactose intolerant viewed their intolerance as a motivator to monitor and be aware of their calcium intake. This view was shared by both genders.

'I make a conscious effort to eat more calcium, but I can imagine that if you are not you wouldn't care that much about it' (male, P22 FG3)

'I am lactose intolerant; it is a concern for me' (female, P13 FG2)

When asked for the reasons for low calcium intake, most participants considered they were consuming sufficient amounts already. A few females indicated having other priorities or areas of concern (i.e. amount of vegetables, iron or protein).

'As a woman, iron is a priority and everything else is put to the side' (female, P39 FG5)

'I think I'm pretty healthy but I don't think of how much calcium I eat, I think more about how many vegetables have I eaten today not how much calcium have I consumed' (female, P6 FG1)

'I don't focus on it, but I would be interested in focusing on it, I concentrate more on protein' (female, P26. FG4)

Participants highlighted not being able to see calcium deficiency as an immediate threat and labelled it as a 'future self-problem'.

‘I have never gone out of my way to seek calcium; I have thought about vegetables but I have never thought to increase calcium’ (female, P25 FG4)

Respondents did not consider calcium as something to worry about if they were trying to be healthy. Calcium intake was more associated with children and older adults by participants.

‘The whole invincible age bracket where you are not thinking about the future, it is “future me” problem’ (female, P18, FG3)

A participant suggested combining the message with an immediate goal, such as protein intake.

‘Most dairy products are high in protein so for men, who are usually more concerned with protein intake’ (female, P6, FG1) Participants were asked to voice their opinions on strategies that would be helpful to motivate young adults to consume more calcium-rich foods. Respondents suggested the use of Australian statistics to highlight the problem of inadequacy.

‘Use 70% of females don’t get enough’ (female, P24, FG3)

Participants were surprised once informed about the levels of inadequacy in the young adult population and suggested incorporating the statistics in an intervention.

‘Statistics give credibility, give the numbers and science’ (male, P22 FG3)

‘I wasn’t aware of the statistics, having that on Facebook would be quite effective’ (female, P37 FG5)

Both male and female participants suggested that educating young adults about the health benefits of calcium, and the risks of not consuming enough was important to acquire attention.

‘Highlighting the risks of calcium deficiency in our age group, it is not very apparent’ (female, P10 FG2)

‘Maybe linking deficiency to a certain issue, unless there is an evident issue then people won’t pay attention’ (male, P16 FG2)

‘What could happen if we are not consuming calcium in the long term, we are not facing any health problems now, but calcium deficiency can affect us in the long term’ (female, P24 FG3)

Participants suggested the importance of highlighting calcium-rich foods to younger groups may help to improve consumption in young adulthood. Subjects recalled learning about excess fat or salt, as well as health consequences such as heart disease, when children but could not remember learning about calcium and its long term health benefits. Many participants indicated that they would make more of an effort if they knew the consequences of not consuming adequate calcium. This view was shared by both genders.

‘If I knew the negatives then it would influence my behaviour’ (female, P28 FG4)

‘We never really got taught about calcium, if you have kids learning about calcium then by the time, they reach our age then they may think about it more and focus on it more’ (female, P25 FG4)

‘Get the kids into the habit and they will continue it’ (male, P29 FG4)

Participants suggested that cooking videos and recipe demonstrations could be used for meal planning and role-modelling.

‘I think meal planning so you know what ingredients you need, and be organised rather than being last minute and getting fast food . . . it’s just having that there as an example for people to look to, so they don’t have to go out of their way to do more research on it. It is easy for them, just scrolling through to see something may be healthy’ (female, P26, FG4)

‘Raise awareness about how much common foods calcium foods have, a lot of them don’t have very much calcium, people think they are getting enough but they don’t eat enough of

the foods that have higher amounts of calcium, they are always under but they don't know about it' (male, P30, FG4)

5.8 Discussion

Young adults have an apparent lack of knowledge about the sources and amount of calcium-rich foods needed to meet calcium requirements. They were largely unable to identify any sources other than dairy, and were unsure about the relationship between calcium intake and development of osteoporosis. The perceived lack of susceptibility for young people was demotivating with respect to consumption.

Our findings are generally in agreement with a similar study reporting barriers and facilitators from adolescents that included personal knowledge gap, misconceptions related to benefits, taste, parental and peer influence, and the availability and convenience of dairy products (36). Although previous studies report a gap in young adults' knowledge of high calcium foods (14,37), a majority of the participants were able to identify the importance of calcium for bone health, which is consistent with a Canadian study (20) and an older study in young women (38). Previous studies have identified that young adults perceive osteoporosis as an older woman's disease (39,40). Respondents were also less aware of the role of calcium in preventing major chronic diseases, which has been known to be a common issue across all age groups (41).

The written questionnaire responses participants completed after the focus group discussion implied that the majority had learnt something new and some realised that their intake was inadequate. Previous findings suggest that a majority of women considered they had sufficient calcium intake because they were unable to correctly quantify the amount of calcium in foods (14,37). Our study participants suggested that the calcium recommendations

be made more relatable by presenting requirements as food servings (i.e. cups of milk or slices of cheese) as opposed to presenting requirements in milligrams. These attitudes can give rise to the belief that calcium intake does not require concern and therefore they act as a barrier to further intake of calcium-rich foods. Respondents were unaware at which life-stage calcium consumption was most important for the prevention of osteoporosis, which is consistent with the Canadian study (20).

With regard to enablers to calcium intake, many indicated a possible willingness to improve their intakes if they had been made aware of the benefits of calcium with respect to certain diseases in the short and long-term or national statistics concerning the proportion of young adults not consuming adequate amounts. A knowledge of recommended intakes, health benefits and critical times to consume calcium was also previously identified as an important enabler to calcium consumption (41,42). Previous studies have reported lower intakes in participants who were unaware of the health benefits of a calcium-rich diet (41), whereas those who were knowledgeable consumed more calcium (42).

Most participants from our study indicated being time-poor and reliant on easy to grab options. This is similar to other findings where young adults reported purchasing foods that require little preparation or cooking effort so that they could spend their time on other activities (43,44). Cost and convenience of foods were considered to be highly important for this age group (45), particularly for those living away from the parental home. Research in this field suggests that young adults have a tendency to purchase foods that provide them with the most value for money (46) and they often choose the cheapest item (20). By contrast to beliefs in Canada (20), dairy products such as milk were seen as inexpensive in Australia, which enabled consumption.

Although our participants did not report themselves to be influenced by their real-life peers, they considered that a social media aspect could increase awareness and the intake of calcium. However, concerns were raised regarding the credibility of information, the issue of trust and the source of information, which is consistent with recent findings (20,47). Our findings are similar to a recent focus group where participants suggested social media as a primary intervention platform and considered it to be a beneficial way of providing dietary advice (44). By contrast, the Canadian young adults perceived that social media would be ineffective (20). The participants in our study suggested new ways to convey information (i.e. memes, funny videos and quizzes). Although the suggestions made by participants are novel and age-appropriate, there is little evidence of their effectiveness to date (48). Given the newness of social media, further research is needed in this area, particularly because social media is very prevalent in the lives of young adults (49).

Taste was a major reason for eating calcium-rich foods and is consistent with previous literature about food choices (43,44,46). Some foods were unlikely to be consumed (i.e. anchovies, sardines and tofu), even with education, unless the taste perception could be improved with appealing recipes. Environment and culture was an important enabler in the consumption of calcium-containing foods as has been reported for other dietary components (19,50–53). Participants recalled the emphasis on calcium and bones put forward by their parents in childhood. As a result, they were able to retain their consumption habits. Other studies have reported on the positive role-modelling from family, especially during adolescence (54,55). This idea is shared across literature as parental modelling where the importance of habit formation is illustrated in early childhood and, as a result, this continues throughout young adulthood (56). Focusing on young adults may have benefits to the next generation of children.

In our focus groups, participants reported the consumption of milk because of the perceived energy it provided, which was also noted by Marcinow et al. (20). We did not find gastrointestinal symptoms or other negative health impacts to be a problem in the present study. However, earlier studies have reported such symptoms to be a barrier to consumption (37), particularly for women who report more negative feelings after dairy consumption compared to men, with gastrointestinal disagreement being one of the most common concerns (14). Fat was not of concern and foods substituted with fat-free or low fat milk varieties were seen as an alternate. However, this is in contrast to other findings where women regarded the fat and calorie content of milk as high and therefore avoided consumption (14, 57).

Despite participants indicating that knowledge would be motivating, previous research has shown that knowledge alone may be insufficient to elicit behaviour change (58). It has been suggested that young adults must be made aware of their calcium intake first to be able to make a change with their intake (59). The participants in our study reported on early influences received from their parents which resulted in them continuing their habits. It was suggested that the consumption of other calcium-rich foods should become a habit from childhood. This idea has also been raised in previous literature where subjects have proposed that education concerning calcium-rich foods at school or by their parents could possibly enable their consumption to become a habitual practice into adulthood (20, 43). A recent study highlighted key gaps with respect to Nutrition and Food Sciences curriculum in Australian schools, such that it is considered to be insufficient and untranslatable for everyday practices (60). Future interventions should create an environment where both children and adolescents receive education about calcium and its health-related outcomes. As suggested by previous studies, culture and traditions play an important role in shaping dietary practices, which cannot be overlooked (61). The combination of positive parental influence

and development of habits from early childhood are likely to result in a positive impact and a continuation of dietary habits in young adulthood.

5.8.1 Strengths and limitations

To our knowledge, this is the first study to report on enablers and barriers to calcium intake in Australia. The use of qualitative research is both an important strength and a limitation of this explorative study. Qualitative research allows us to understand not only the what, but also the how and why, which is important when examining at the beliefs and attitudes of young adults. Conversely, limitations of the use of focus groups may be that individuals felt insecure about sharing their thoughts and opinions or may have been pressured to conform their opinions to the rest of the group (27). As with most studies, using a convenience sample of volunteers introduces self-selection bias, despite attempts to broaden the scope of participants who were recruited. Young adults are more likely to volunteer if they are health or nutrition conscious where females are over-represented. Another limitation is that most participants were enrolled in tertiary education. However, 56% of the Australian population have tertiary level qualifications: diploma, certificate or degree (62).

5.8.2 Conclusion and practical implications

The focus groups provided insight into perceived barriers and enablers to the consumption of calcium-rich foods, highlighting how capability, opportunity and motivation can impact behaviours with respect to the consumption of adequate dietary calcium in young adults. Although young adults were aware of the main health benefits of calcium in relation to bone health, a large gap in knowledge was identified regarding nondairy sources, health benefits in preventing disease, and recommended amounts. With regard to opportunity, cost concerns were raised for cheese, with milk being labelled as inexpensive and convenient. Young adults

identified taste, family and cultural practices as motivators and also reflected on their reasons for low intake (i.e. having other priorities or labelling it as a 'future me' problem). This identifies the need for future nutrition interventions to emphasise the self-assessment of current calcium intake as a primary step towards reaching the recommended intake. Our findings highlight the need to develop an intervention providing information on social media from a credible source. An age-specific intervention with a focus on education could effectively provide young adults with knowledge to support their behaviour change. Given the role of parental influence and habit formation in childhood, interventions could also focus on promoting other forms of calcium from a younger age, allowing consumption to continue through to adulthood. The findings from the present study will be used to inform the development of a social media intervention for young adults. The intervention will focus on emphasising the existing enablers to calcium-rich foods and overcoming the barriers identified in our study.

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5.10 Conclusion to the chapter

The formative research conducted in this chapter identified the barriers and enablers to calcium intake and how it can fit into the context of the COM-B model for behaviour change. Our findings from this chapter found a large gap in knowledge which would be necessary to address in a future intervention. The findings also highlighted the need for additional support to assist with skills development (such as cooking videos and recipe demonstrations). Social media was seen to be an acceptable platform, with Facebook being ranked as the most preferred platform. The credibility of social media was also questioned and participants voiced the need for a trustworthy and credible source. The next chapter will gather further preferences from young adults and identify messages that are likely to resonate with this age group.

Appendix 5

Appendix 5.1 Ethical approval for the focus groups conducted with young adults

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
Human Research Ethics Committee

Wednesday, 19 April 2017

Prof Margaret Allman-Farinelli
School of Life and Environmental Sciences (SOLES); Faculty of Science
Email: margaret.allman-farinelli@sydney.edu.au

Dear Margaret

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

After consideration of your response to the comments raised your project has been approved.

Approval is granted for a period of four years from **19 April 2017** to **19 April 2021.**

Project title: **Exploring the enablers and barriers to eating foods rich in calcium: a qualitative study using focus groups**

Project no.: 2017/218

First Annual Report due: **19 April 2018**

Authorised Personnel: **Allman-Farinelli Margaret; Clayton Steffani; Rouf Anika;**

Documents Approved:

Date Uploaded	Version number	Document Name
10/04/2017	Version 2	Participant Info Statement
10/04/2017	Version 2	Pre and post questions updated
10/04/2017	Version 2	Recruitment poster Facebook updated
10/04/2017	Version 2	Recruitment poster updated
13/03/2017	Version 1	Focus group questions
13/03/2017	Version 1	Participant Consent Form

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).

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CRICOS 00026A

THE UNIVERSITY OF SYDNEY

- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

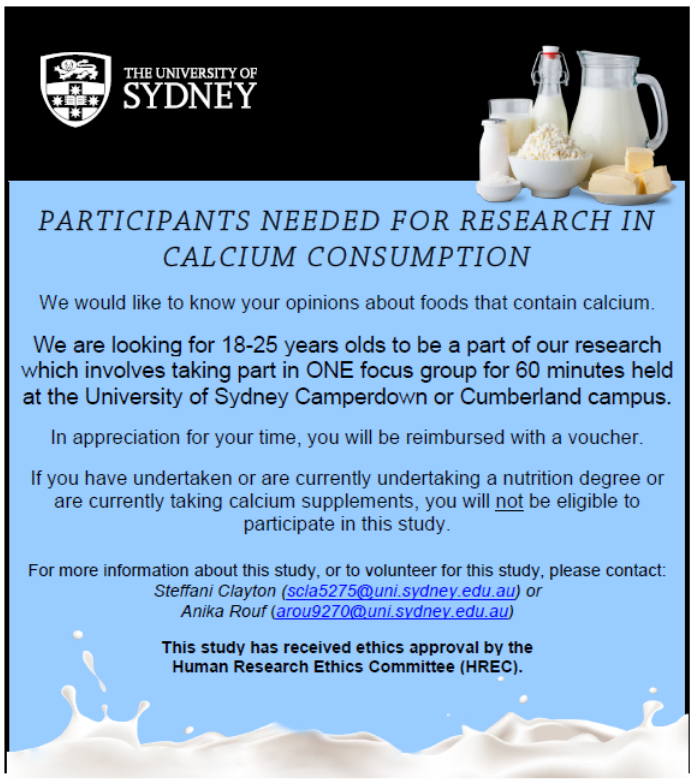
Sincerely

R.L. Shackel

Associate Professor Rita Shackel
Chair
Human Research Ethics Committee (HREC 3)

The University of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007) and the NHMRC's Australian Code for the Responsible Conduct of Research (2007).

Appendix 5.2 Recruitment poster used to invite participants



Appendix 5.3 Participation Information Statement

THE UNIVERSITY OF SYDNEY

Discipline of Nutrition and Dietetics
School of Life and Environmental Sciences
Faculty of Science

ABN 15 211 513 464

Margaret Allman-Farinelli
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Exploring the enablers and barriers to eating foods rich in calcium: a qualitative study using focus group discussions

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study that will involve participating in a focus group to determine what enables people to consume calcium containing products and what may be barriers to them consuming calcium containing products. This study will help to identify how the consumption of calcium containing products can be increased in young adults.

You have been invited to participate in this study because you meet the demographics required for this study. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving your consent to take part in this study you are telling us that you:
- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

The study is being carried out by the following researchers:
- Margaret Allman-Farinelli, Professor of Dietetics
- Anika Rouf, PhD Candidate
- Steffani Clayton, Masters Student

Appendix 5.4 Pre focus group questionnaire

1. What is your gender?

☐ Female ☐ Male

2. What is the highest level of education that you have completed?

☐ Year 10

☐ Year 12

☐ Tertiary (University, TAFE, College)

☐ Other (please specify) _____

3. Do you currently follow any specific diet or health regime that influences your food choices? For example, weight loss program, paleo, vegetarian, vegan, sugar-free). If yes, please identify/explain.

☐ No

☐ Yes (please specify) _____

4. Do you have diagnosed lactose intolerance?

☐ No ☐ Yes

5. Do you think calcium is an important nutrient to include in your diet?

☐ No ☐ Yes

6. If yes, why do you think calcium is important?

_____

_____

7. What types of food do you think are rich in calcium?

_____

_____

8. How important is eating healthy to you?

☐ Very important

☐ Important

☐ Somewhat important, but I have other priorities

☐ Not so important

☐ Not important at all

Appendix 5.5 Post focus group questionnaire

1. Do you think you have gained any new information from this focus group? If yes, please tell us what you have learnt.

☐ No

☐ Yes _____

2. Do you think today's focus group has increased your motivation to eat foods rich in calcium?

☐ No ☐ Yes

3. From your personal experience, what makes it challenging for you to eat foods rich in calcium? Tick more than one if relevant.

☐ I don't have the time to plan what I eat.

☐ I don't think see calcium as being so important to include in my diet.

☐ I don't know where calcium rich foods are found.

☐ I don't think it's worth the cost. I think calcium rich foods are costly.

☐ Other (please specify) _____

☐ Nothing

5. Based on your own opinion, what social media platform would you prefer to see this on?

☐ Facebook

☐ Twitter

☐ Instagram

☐ Other (please specify) _____

6. Would you be interested to participate in an intervention program in the future? If yes, please leave us your email.

☐ No

☐ Yes _____

7. Is there anything else you would like to tell us? Please feel free to write anything that you didn't get to say at the focus group or anything else you consider as important. Your opinion can help us with our research so please don't hold back!

_____

_____

Appendix 5.6

Publication resulting from Chapter Five, *Journal of Human Nutrition and Dietetics*, 2019, 32 (4): 443-454
DOI: 10.1111/jhn.12653

(See next page)

BDA The Association of UK Dietitians
THE OFFICIAL JOURNAL OF THE BRITISH DIETETIC ASSOCIATION
Journal of Human Nutrition and Dietetics

Journal of Human Nutrition and Dietetics

RESEARCH PAPER

The barriers and enablers to achieving adequate calcium intake in young adults: a qualitative study using focus groups

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Keywords
barriers, behavioural theory, calcium, dairy, diet, young adults.

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†These authors contributed equally to the present study.

Abstract

Background: Despite the established benefits of calcium consumption, many young Australians are not meeting the recommendations for calcium intake. This is concerning because an adequate calcium consumption is important throughout young adulthood to reach peak bone mass and for the prevention of osteoporosis. Therefore, the present study aimed to explore the barriers and enablers to consuming calcium-rich foods with young adults.
Methods: Using a semi-structured question guide, five focus group discussions were conducted with 39 participants [mean (SD) age 22.5 (1.8) years]. Participants were mostly females (n = 29) and enrolled in tertiary education (n = 31). A deductive approach was used to group common ideas into themes. The findings from the focus groups were analysed using the COM-B framework, which examines the interactions between three key components (i.e. capability, opportunity and motivation).
Results: On examining the young adults' capability to consume a diet adequate in calcium, it was found that young adults had limited knowledge of sources, prevention of disease and recommended amounts. Some participants voiced physical barriers to consumption (lactose intolerance). Opportunity was reported as a physical (availability of calcium-rich foods), financial and social opportunity. Some participants reported motivation to include dairy as a result of the habit becoming engrained during their childhood under parental influence (automatic motivation), whereas others reflected on a lack of awareness relating to inadequacy and health consequences (reflective motivation).
Conclusions: Although social media was seen to be an acceptable mode of intervention, concerns were raised about the source and credibility of the information. The findings may inform the development of future interventions targeting eating habits of young adults.

Introduction

Calcium requirements during adolescence into young adulthood are of significant importance [1]. It has been demonstrated that the calcium intake during growth may influence peak bone mass and that a deficiency in calcium intake can lead to low bone density or osteoporosis later in life [2]. Around 99% of the body's calcium is found within the bones to provide structure and strength [3]. It is an important nutrient required during growth to ensure the development and maintenance of the skeleton [4]. Calcium is also important with respect to blood pressure regulation [5], cancer protection [6–8], obesity prevention [9,10] and diabetes prevention [11,12]. Despite the many benefits of calcium consumption, most young Australians are not meeting the recommendations for calcium intake [13]. The latest National Nutrition and Physical Activity Survey (NNPAS) 2011–2012 states that approximately

44% of males and 71% of females fail to meet the estimated average requirement for calcium [13]. These numbers are concerning and indicate the need to determine an effective way of increasing calcium consumption in young adults.

A number of studies have looked at common barriers to eating calcium-containing foods, although there has been limited research conducted exclusively in young adults. In the general population, the reported barriers included a lack of knowledge regarding nondairy calcium-rich foods [14]; the belief that all dairy foods are high in calories, cholesterol [14–16] and fat [17]; the cost of milk compared to other beverages [17]; and perceived versus real lactose intolerance [18]. Studies have also examined common enablers and motivators to consume calcium-containing foods, which included association with positive outcomes such as stronger hair and nails and more energy; awareness of peak bone mass; and prevention of osteoporosis [19,20]. However, many of these studies have focused exclusively on the views and attitudes towards dairy products and have not extended this to all calcium-rich foods. This concept is original and emphasises the need and importance of the present study. In addition, only one Canadian study [20] has explored the perception of calcium in young men and women and so the present study conducted in Australian 18–25-year-old adults is novel.

To develop ways and strategies that help increase calcium consumption, it is important to gain an insight into eating behaviours, beliefs, attitudes and knowledge so that an effective intervention can be developed. The current research also examines opinions about the use of social media for an intervention aiming to improve calcium consumption. Over the last decade, the use of the Internet and digital media has increased significantly, allowing an extra avenue for health education to be delivered. The World Health Orgnaization defines eHealth as the use of the modern information and communication technologies for health [21] and mHealth is a sub-category that refers to the use of mobile devices in a medical or public health setting [22]. Internet and smartphone-delivered public health interventions have recently emerged and gained momentum [23], leading to an opportunity to use social media to address issues such as calcium inadequacy. The current research explores the barriers and enablers to the calcium consumption in Australian young adults (18–25 years old) and informs the development of a new social media intervention in young adults if this delivery channel is acceptable to the target group. An age range of 18–25 years was used in the present study because this represents the period in adulthood where calcium intake has the greatest impact on peak bone mass development [24,25].

Materials and methods

The materials and methods used for the focus groups were approved by the Human Research Ethics Committee at the University (HREC). The ethics approval number is 2017/218.

Recruitment

Men and women aged between 18–25 years were eligible to participate. Participants were recruited via Facebook, tab-flyers and active face-to-face recruitment. A recruitment flyer was posted on Facebook and sent to existing friends, connections and public groups within networks of the researchers conducting the study. The flyer was shared to enable a greater reach of participants. Tab-flyers were posted on public notice boards that were widely viewed, such as in food courts and kitchens, as well as in public places around university campus, such as bathrooms. Participants were actively recruited via announcements at the start of lectures and face-to-face active recruitment on campus.

People interested in the study e-mailed the researchers and a member of the research team then screened individuals for eligibility. Participants were given an information sheet to provide them with more information about the study and what was required of them. If they remained interested, they were booked into a focus group session. Participants were offered a $10 store voucher as a reimbursement for their time. The amount was not specified in the recruitment material. Participants were excluded if they had undertaken or were currently undertaking a nutrition-related subject or degree. Participants were also excluded if they were regularly consuming calcium supplements because of their demonstrated knowledge of calcium and the effects it has on health [26].

Procedures

Participants were allocated to a focus group session at a time convenient to them. Five focus groups were conducted over two consecutive weeks in rooms on a university campus. This was to ensure a range of participant responses, as well as for satisfactory theoretical saturation to be reached [27]. Data saturation was defined as collection of data until there were fewer surprises with the responses and no new themes emerged [28]. The focus groups were led by a female facilitator (AR, dietitian and PhD researcher). A moderator (SC, student dietitian) was present to record group dynamics and nonverbal communication, as well as to assist with time-keeping. Focus groups were audiotaped to enable systematic analysis of the discussions. The size of the groups ranged from six to

nine participants and each ran for approximately 1 h in duration.

Upon arrival, participants provided their written informed consent to the audiotaping of the focus group and completed a short questionnaire. Data collected included demographics (age, gender, education level), whether they followed a specific diet (e.g. vegetarian, sugar-free, calorie-restricted) or had lactose intolerance, and whether they considered it important to include calcium, naming calcium-containing foods and rating the importance of eating healthily. After completion of the focus group, an additional questionnaire was administered to determine whether their views had changed in regard to knowledge gain or motivation to eat foods rich in calcium, as well as to gain an insight into their personal barriers and determine their preference for a social media platform.

The focus group structure followed the methods suggested by Krueger and Casey [27] to ensure good discussion and exploration of themes. The focus group discussion was semi-structured to ensure consistency with respect to the information given to all the groups and allowed for some level of flexibility in the discussion by participants [29]. The discussion focused on the participant's general knowledge of calcium, how they viewed their personal intake of calcium and calcium-containing foods in terms of adequacy and inadequacy and the factors affecting calcium intake, as well as the personal enablers and barriers to consuming particular foods containing calcium and whether obtaining sufficent calcium is actually a concern of people their age (Table 1). Finally, participants were asked for suggestions regarding effective ways to convey the importance of consuming calcium-containing foods in the diet and whether they considered the use of social media for an intervention would be acceptable and appropriate.

Table 1 Line of questioning developed and used in focus groups to gather information on the barriers and enablers of consuming calcium-containing foods

Focus Group Questions
General Calcium Knowledge
What do you know about calcium?
Do you know how much you should be having every day?
Why it is good for our health?
What comes to mind when you think of sources of calcium in the diet Where do you think these are found?
What do you think is the best source of calcium in the diet? What is your understanding of calcium-rich foods
How much is one serving?
Do you think getting enough calcium is a concern of people in your age group
Is getting enough calcium a concern for you?
Information about personal calcium intake/factors affecting calcium intake
What are the main calcium-containing products you consume?
What do members in your family usually consume?
What are the beverages you drink throughout the day?
Thinking about the calcium-containing products that you do consume, why do you consume these particular products
What are some foods that you know contain calcium but that you do not consume
Why do you not consume them?
Is the fat content in dairy products a concern for you?
Does the cost of calcium-rich food influence your ability to meet your calcium goal
Do you think eating foods rich in calcium is time consuming/too expensive/not affordable
Improving calcium intake
Are there any strategies that you use to help make sure you are getting enough calcium in your diet
What strategies would be helpful to motivate you to consume more calcium-rich foods
Do you think social media could be incorporated into reminding people your age about the importance of consuming calcium or even used as a reminder
What would you consider to be the most effective way to convey messages about the importance of getting enough calcium in your diet to people in your age group

Data collection and analysis

By the end of the fifth focus group, the researchers came to the conclusion that saturation in themes had been reached and no new ideas were being generated. Data were analysed following the completion of all the focus groups and each audiotape recording was transcribed. Transcripts were checked for quality control and then imported into NVIVO, version 11.0.0317 (QSR International Pty Ltd, Melbourne, VIC, Australia), comprising software that is commonly used for the analysis of qualitative research. Analyses were guided by Knodel [30] and Hsieh & Shannon [31], which involved determining patterns in ideas and their frequency.

An initial set of codes were developed corresponding to the categories of questions (i.e. general calcium knowledge, factors affecting intake and strategies to improve calcium intake). All participant responses were then grouped and coded for frequency. Codes were also identified from previous research conducted on this topic that addressed common themes such as cost and knowledge [20,32]. A deductive reasoning approach was used that involved moving from general to specific information. The themes were then grouped using the COM-B framework which examines the interactions between three key components (i.e. capability, opportunity and motivation), and is a well-known method for analysing target behaviours and developing behaviour change interventions [33]. Michie *et al.* proposed that an individual requires

capability (C), opportunity (O) and motivation (M) to perform a certain behaviour (B) [34,35]. The COM-B model, which aims to guide the understanding of behaviour, proposes that an individual must be physically and psychologically capable; have the social and physical opportunity; and have the motivation as an automatic process or as a result of reflective processes (intention or choice) to engage in behaviour change. Once the analyses were completed, the research team met to discuss results and determine the final codes. The coding was cross-checked by another researcher to ensure accuracy. Differences in responses between females and males were also explored using NVIVO. The synthesis of the findings presents the general themes and supportive quotes from the focus groups identified by P (participant) and FG (focus group) number.

Results

Participants included men and women from a large urban university, as well as those who worked full-time. In total, 39 young adults (10 men) participated in five focus groups [mean (SD) 22.5 (1.8) years]. The majority were female and completing tertiary education. Demographic information is summarised in Table 2. The majority of participants did not follow a specific health regime ($n = 28$). Some diets that were mentioned by 11 participants included the 5 : 2 diet, monitoring calorie intake, weight loss, limited dairy intake, gluten free, limited sugar, vegetarian and pescetarian. The responses to the pre- and post-focus group questionnaire are summarised in Table 3. A majority of young adults were aware of dairy as a good source of calcium and related the importance of calcium to bones, health or strength. The most reported knowledge learnt from the focus groups comprised new sources of calcium or calcium content of foods. A lack of time was also stated as the main barrier to eating foods rich in calcium.

Enablers and barriers to eating sufficient calcium-rich foods identified five themes from participant responses. First, psychological capability was dependent on general calcium knowledge; physical opportunity and automatic motivation determined the enablers, whereas psychological capability, physical capability and reflective motivation described the barriers. Finally, social opportunity and reflective motivation supported ways of improving calcium intake, and social opportunity also highlighted the influence of social media.

Table 2 Focus group participant demographic information ($n = 39$)

Characteristics	Group ($n = 39$)
Age (years), mean (SD)	22.5 (1.8)
Gender, *n*	
Male	10
Female	29
Highest level of education, *n*	
Year 10	0
Year 12	5
Tertiary	31
Other	3

Capability

Psychological

When considering psychological capability, the majority of the participants reported a lack of knowledge about calcium. Four themes were identified, which included bone health, physiological processes requiring calcium, recommended intakes and food sources of calcium. A majority of participants associated calcium with bone health and strength. However, only some respondents were able to identify the role of calcium in osteoporosis and bone health.

> 'Good for bone strength' (female, P5 FG1)
> 'Good for preventing osteoporosis' (male, P21 FG3)
> 'I think consumption of calcium in adolescence determines your bone health later in life' (female, P27 FG4)

Some respondents were aware of the role of calcium for their physiological processes with comments.

> 'Essential in many cellular processes' (female, P7 FG1)
> 'Important for physiological function, such as cell signalling' (female, P10 FG2)
> 'Essential for heart and blood supply system work' (female, P17 FG3)

A few female participants demonstrated knowledge in relation to menopause.

> 'Women stop absorbing calcium at a certain age, it slows down' (female, P19 FG3)
> 'During menopause, more leaches out of your bones' (female, P18 FG3)

Some participants could indicate the recommended calcium intake in milligrams, yet they were unable to translate this to food amounts. A few young adults openly admitted not knowing the recommendations for their age group.

> 'I don't really know what the recommended is or what you are meant to have' (female, P19 FG3)

With regard to sources of calcium, most participants identified milk and dairy products as the main source of calcium. A smaller number identified leafy green vegetables and fish as a source of calcium. Meat was incorrectly

Table 3 Summary of responses from pre and post questionnaire

Question	Response
Pre-focus group questionnaire	
Do you currently follow any specific diet or health regime that influences your food choices For example, weight loss program, paleo, vegetarian, vegan, sugar-free). If yes, please explain.	Yes (n = 11)
	No (n = 28)
Do you have diagnosed lactose intolerance?	Yes (n = 2)
	No (n = 37)
Do you think calcium is an important nutrient to include in your diet	Yes (n = 39)
	No (n = 0)
If yes, why do you think calcium is important?	'bone strength' (n = 13)
	'bone density' or 'osteoporosis' (n = 3)
	'cellular process' or a physiological function (n = 6)
	'bones' or 'maintenance' (n = 9)
	'bone health (n = 6)
	'bone development' (n = 5)
	'teeth' (n = 5)
	Other (n = 4)
What types of food do you think are rich in calcium?	'dairy' (n = 13)
	'milk and cheese' (n = 9)
	'milk, cheese and yoghurt' (n = 10)
	'leafy greens' or 'some vegetables' (n = 5)
	'almonds' or 'nuts' (n = 3)
	'fish' or 'seafood' (n = 5)
	'tofu' (n = 2)
	A specific vegetable (i.e. spinach, kale) (n = 2)
How important is eating healthily to you?	Very important (n = 14)
	Important (n = 19)
	Somewhat important, but I have other priorities (n = 6)
Post-focus group questionnaire	
Do you think you have gained any new information from this focus group	Yes (n = 38)
	No (n = 1)
If yes, please tell us what you have learnt.	New sources of calcium or calcium content of foods (n = 27)
	RDI or amount of calcium required (n = 13)
	Statistics on inadequacy or deficiency (n = 5)
	Importance of calcium (n = 5)
	Realised not getting enough (n = 4)
Do you think today's focus group has increased your motivation to eat foods rich in calcium	Yes (n = 36)
	No (n = 3)
From your personal experience, what makes it challenging for you to eat foods rich in calcium Tick more than one option, if relevant.	I don't have the time to plan what I eat (n = 21)
	I don't see calcium as being so important to include in my diet (n = 10)
	I don't know where calcium-rich sources are found (n = 7)
	I don't think it's worth the cost. I think calcium rich foods are costly (n = 7)
	Other (n = 15)
	Nothing (n = 3)
What social media platform would you prefer to learn from?	Facebook (n = 32)
	Instagram (n = 21)
	Twitter (n = 1)
	Other (n = 8)

identified as being high in calcium. Females provided a broader range of sources of calcium, which included soy, tofu and beans, compared to males. When prompted further, the source of the knowledge was reported as general learning, media such as television advertisements and the influence of their parents.

> 'I instantly think of dairy products like cheese, yoghurt' (female, P8 FG3)
> 'I think some vegetables; I don't know which ones specifically' (female, P13 FG2)

When asked about strategies that may improve intake, respondents suggested that an intervention may be appropriate for raising awareness of other sources of calcium and how much calcium they contained. Participants also raised the desire for calcium requirements to be presented in a form that is relatable to common foods and portion sizes.

> 'I don't know what 1000 mg looks like, I would prefer saying like have a glass of week to get your amount' (female, P21 FG3)

Physical

The participants raised the issue of lactose intolerance and recognised friends placed themselves on dairy-free diets without seeking any medical advice. Some female participants said dairy products made them feel 'really full' or 'not too great'.

> 'More of a craze to go dairy-free than have dairy' (female, P5 FG1)

Opportunity

Physical

Cost and convenience were seen to be important motivators to consume dairy products. Participants indicated that cost was important to them and the price of milk was an important factor. Participants reported the relatively cheap price of milk in Australia as their top reason for purchase.

> 'I think dairy which is the main thing we think of is pretty affordable, milk is very affordable' (female, P13 FG2)

Respondents appreciated the convenience of some dairy products and reported enjoying this aspect.

> 'It's not time consuming to put milk on your cereal' (male, P3 FG1)
> 'It's convenient to grab a tub of yoghurt to leave the house or something' (male, P8 FG1)

Although participants were unconcerned about the cost of milk saying it was inexpensive, they viewed the waste as a concern because containers were large and limited shelf life. The main concern arose from size of the container for milk or yoghurt; however, it was only by young adults who lived out of home or cooked for themselves.

> 'That's money wasted if I don't finish it' (female, P9 FG2)

Some other sources of calcium were viewed as too expensive, such as cheese, almonds and fish. Participants also acknowledged the higher cost of lactose-free products and stated it would be more difficult to reach calcium recommendations for those with intolerance.

> 'If you look at the lactose-free alternatives, I would feel like they might be more expensive, if you were lactose intolerance then it might be harder to meet calcium goals' (female, P18 FG3)

Social

Participants in our focus groups did not report any current social opportunities in relation to their calcium intake. However, respondents suggested the use of public figures or celebrities and cross-platform campaigns to create awareness of the need for calcium consumption. Although respondents considered the latter to be an appropriate medium to seek the attention of young adults on social media, concerns were raised about the source and credibility of the information and its appeal to young adults. Subjects raised the issue of trust when it came to social media as a result of the amount of information on this platform. The participants reiterated the need for a 'trustworthy source' if information of calcium were to be put onto social media. Participants were concerned about the location and access of accurate information on social media, as illustrated by the following quotes.

> 'I think it's difficult with social media, you are not going to follow calcium or dietitian unless you are already conscious about or aware of that, in order to get a wide audience, something where people who aren't really thinking about it is your target, people who aren't exposed to it or conscious of it' (female, P18, FG3)
> 'I auto tune some of it out because it is hard to trust, I like The Conversation website, scholarly articles which are done in a more understandable way, if this could be shared through avenues like Facebook more often, something that I trust, sharing it through trustworthy platforms' (female, P4, FG1)

Furthermore, participants said that information would have to be appearing in a catchy manner as they would otherwise 'just scroll past it', as stated by a participant

(male, P13 FG2). Participants suggested memes, funny videos or fun quizzes about calcium consumption as possible ways to obtain the attention of young adults on social media. Some participants were able to recall past media campaigns that heavily relied on celebrities, such as the 'Got Milk' advertising campaign from the USA. Respondents suggested ideas similar to 'Milk Moustache' to gain appeal among young adults and investing on social media ads. Creating a short summary of research articles was also raised as a method to create awareness.

> 'There used to be the "Got Milk" in America with celebrities, maybe if you used Instagram or other forms of social media with endorsements' (female, P18, FG3); 'maybe put an ad before YouTube videos, compulsory ads' (P21, FG3)
> 'Maybe Facebook ad, they pop up and can lead to something else, maybe to calculate how much you are eating' (P19, FG3)

Motivation

Automatic

Taste was highlighted by participants as the top reason for consuming calcium-containing products, particularly dairy foods. Another stated that it was a good source of energy.

> 'I have Greek yoghurt for breakfast because it's delicious and I know it's good for me' (female, P39 FG5)
> 'I think, for me, the energy I get from it' (female, P26, FG4)

Participants indicated the family environment as having an effect on their calcium intake and knowledge as a result of their mothers positively influencing their dairy consumption in childhood.

> 'I think with calcium it was more my mum forcing me to have milk, I still have it now' (male, P30 FG4)
> 'When I was little, my mum told me it would make me grow' (female, P25 FG4)

Cultural practices were referred as another reason for consumption of milk. A few respondents stated that dairy products were popular and traditional in their culture.

> 'In our culture, it is just engrained to have a glass of milk for strong healthy bones' (male, P8 FG1)
> 'I feel like it would be more habit or what you are used to, I have always grown up drinking milk or milk in the tea, difficult if you are on your own if you aren't thinking about for you to put calcium-rich foods in your diet' (female, P18, FG2)

Reflective

Although fat content was never raised by participants as a barrier to consuming calcium-containing products, participants voiced their opinions, once probed. Some participants expressed concern about the fat content of cheese, whereas many others had no concern about the fat content of dairy products at all.

> 'I am conscious of eating it, knowing that cheese has a higher amount of fat' (male, P8 FG1)

Comments made on fat content were compared between genders. Female participants were aware of the fat content of dairy foods, compared to males. Although some females stated their concerns, the majority of them mentioned switching to low fat or skim milk and did not appear to alter their overall intake of milk.

> 'I don't look at the fine print of the label, but if the front says lite then I will buy that' (female, P38 FG5)
> 'When I am at home I drink lite milk, when I am out I drink skim' (female, P18 FG3)

Participants who reported themselves as being lactose intolerant viewed their intolerance as a motivator to monitor and be aware of their calcium intake. This view was shared by both genders.

> 'I make a conscious effort to eat more calcium, but I can imagine that if you are not you wouldn't care that much about it' (male, P22 FG3)
> 'I am lactose intolerant; it is a concern for me' (female, P13 FG2)

When asked for the reasons for low calcium intake, most participants considered they were consuming sufficient amounts already. A few females indicated having other priorities or areas of concern (i.e. amount of vegetables, iron or protein).

> 'As a woman, iron is a priority and everything else is put to the side' (female, P39 FG5)
> 'I think I'm pretty healthy but I don't think of how much calcium I eat, I think more about how many vegetables have I eaten today not how much calcium have I consumed' (female, P6 FG1)
> 'I don't focus on it, but I would be interested in focusing on it, I concentrate more on protein' (female, P26. FG4)

Participants highlighted not being able to see calcium deficiency as an immediate threat and labelled it as a 'future self-problem'.

> 'I have never gone out of my way to seek calcium; I have thought about vegetables but I have never thought to increase calcium' (female, P25 FG4)

Respondents did not consider calcium as something to worry about if they were trying to be healthy. Calcium intake was more associated with children and older adults by participants.

> 'The whole invincible age bracket where you are not thinking about the future, it is "future me" problem' (female, P18, FG3)

A participant suggested combining the message with an immediate goal, such as protein intake.

> 'Most dairy products are high in protein so for men, who are usually more concerned with protein intake' (female, P6, FG1)

Participants were asked to voice their opinions on strategies that would be helpful to motivate young adults to consume more calcium-rich foods. Respondents suggested the use of Australian statistics to highlight the problem of inadequacy.

> 'Use 70% of females don't get enough' (female, P24, FG3)

Participants were surprised once informed about the levels of inadequacy in the young adult population and suggested incorporating the statistics in an intervention.

> 'Statistics give credibility, give the numbers and science' (male, P22 FG3)
> 'I wasn't aware of the statistics, having that on Facebook would be quite effective' (female, P37 FG5)

Both male and female participants suggested that educating young adults about the health benefits of calcium, and the risks of not consuming enough was important to acquire attention.

> 'Highlighting the risks of calcium deficiency in our age group, it is not very apparent' (female, P10 FG2)
> 'Maybe linking deficiency to a certain issue, unless there is an evident issue then people won't pay attention' (male, P16 FG2)
> 'What could happen if we are not consuming calcium in the long term, we are not facing any health problems now, but calcium deficiency can affect us in the long term' (female, P24 FG3)

Participants suggested the importance of highlighting calcium-rich foods to younger groups may help to improve consumption in young adulthood. Subjects recalled learning about excess fat or salt, as well as health consequences such as heart disease, when children but could not remember learning about calcium and its long-term health benefits. Many participants indicated that they would make more of an effort if they knew the consequences of not consuming adequate calcium. This view was shared by both genders.

> 'If I knew the negatives then it would influence my behaviour' (female, P28 FG4)
> 'We never really got taught about calcium, if you have kids learning about calcium then by the time they reach our age then they may think about it more and focus on it more' (female, P25 FG4)
> 'Get the kids into the habit and they will continue it' (male, P29 FG4)

Participants suggested that cooking videos and recipe demonstrations could be used for meal planning and role-modelling.

> 'I think meal planning so you know what ingredients you need, and be organised rather than being last minute and getting fast food ... it's just having that there as an example for people to look to, so they don't have to go out of their way to do more research on it. It is easy for them, just scrolling through to see something may be healthy' (female, P26, FG4)
> 'Raise awareness about how much common foods calcium foods have, a lot of them don't have very much calcium, people think they are getting enough but they don't eat enough of the foods that have higher amounts of calcium, they are always under but they don't know about it' (male, P30, FG4)

Discussion

Young adults have an apparent lack of knowledge about the sources and amount of calcium-rich foods needed to meet calcium requirements. They were largely unable to identify any sources other than dairy, and were unsure about the relationship between calcium intake and development of osteoporosis. The perceived lack of susceptibility for young people was demotivating with respect to consumption.

Our findings are generally in agreement with a similar study reporting barriers and facilitators from adolescents that included personal knowledge gap, misconceptions related to benefits, taste, parental and peer influence, and the availability and convenience of dairy products [36]. Although previous studies report a gap in young adults' knowledge of high calcium foods [14,37], a majority of the participants were able to identify the importance of calcium for bone health, which is consistent with a Canadian study [20] and an older study in young women [38]. Previous studies have identified that young adults

perceive osteoporosis as an older woman's disease [39,40]. Respondents were also less aware of the role of calcium in preventing major chronic diseases, which has been known to be a common issue across all age groups [41].

The written questionnaire responses participants completed after the focus group discussion implied that the majority had learnt something new and some realised that their intake was inadequate. Previous findings suggest that a majority of women considered they had sufficient calcium intake because they were unable to correctly quantify the amount of calcium in foods [14,37]. Our study participants suggested that the calcium recommendations be made more relatable by presenting requirements as food servings (i.e. cups of milk or slices of cheese) as opposed to presenting requirements in milligrams. These attitudes can give rise to the belief that calcium intake does not require concern and therefore they act as a barrier to further intake of calcium-rich foods. Respondents were unaware at which life-stage calcium consumption was most important for the prevention of osteoporosis, which is consistent with the Canadian study [20].

With regard to enablers to calcium intake, many indicated a possible willingness to improve their intakes if they had been made aware of the benefits of calcium with respect to certain diseases in the short- and long-term or national statistics concerning the proportion of young adults not consuming adequate amounts. A knowledge of recommended intakes, health benefits and critical times to consume calcium was also previously identified as an important enabler to calcium consumption [41,42]. Previous studies have reported lower intakes in participants who were unaware of the health benefits of a calcium-rich diet [41], whereas those who were knowledgeable consumed more calcium [42].

Most participants from our study indicated being time-poor and reliant on easy to grab options. This is similar to other findings where young adults reported purchasing foods that require little preparation or cooking effort so that they could spend their time on other activities [43,44]. Cost and convenience of foods were considered to be highly important for this age group [45], particularly for those living away from the parental home. Research in this field suggests that young adults have a tendency to purchase foods that provide them with the most value for money [46] and they often choose the cheapest item [20]. By contrast to beliefs in Canada [20], dairy products such as milk were seen as inexpensive in Australia, which enabled consumption.

Although our participants did not report themselves to be influenced by their real-life peers, they considered that a social media aspect could increase awareness and the intake of calcium. However, concerns were raised regarding the credibility of information, the issue of trust and the source of information, which is consistent with recent findings [20,47]. Our findings are similar to a recent focus group where participants suggested social media as a primary intervention platform and considered it to be a beneficial way of providing dietary advice [44]. By contrast, the Canadian young adults perceived that social media would be ineffective [20]. The participants in our study suggested new ways to convey information (i.e. memes, funny videos and quizzes). Although the suggestions made by participants are novel and age-appropriate, there is little evidence of their effectiveness to date [48]. Given the newness of social media, further research is needed in this area, particularly because social media is very prevalent in the lives of young adults [49].

Taste was a major reason for eating calcium-rich foods and is consistent with previous literature about food choices [43,44,46]. Some foods were unlikely to be consumed (i.e. anchovies, sardines and tofu), even with education, unless the taste perception could be improved with appealing recipes. Environment and culture was an important enabler in the consumption of calcium-containing foods as has been reported for other dietary components [19,50–53]. Participants recalled the emphasis on calcium and bones put forward by their parents in childhood. As a result, they were able to retain their consumption habits. Other studies have reported on the positive role-modelling from family, especially during adolescence [54,55]. This idea is shared across literature as parental modelling where the importance of habit formation is illustrated in early childhood and, as a result, this continues throughout young adulthood [56]. Focusing on young adults may have benefits to the next generation of children.

In our focus groups, participants reported the consumption of milk because of the perceived energy it provided, which was also noted by Marcinow *et al.* [20]. We did not find gastrointestinal symptoms or other negative health impacts to be a problem in the present study. However, earlier studies have reported such symptoms to be a barrier to consumption [37], particularly for women who report more negative feelings after dairy consumption compared to men, with gastrointestinal disagreement being one of the most common concerns [14]. Fat was not of concern and foods substituted with fat-free or low fat milk varieties were seen as an alternate. However, this is in contrast to other findings where women regarded the fat and calorie content of milk as high and therefore avoided consumption [14,57].

Despite participants indicating that knowledge would be motivating, previous research has shown that knowledge alone may be insufficient to elicit behaviour change [58]. It has been suggested that young adults must be made aware of their calcium intake first to be able to make a change with their intake [59]. The participants in

our study reported on early influences received from their parents which resulted in them continuing their habits. It was suggested that the consumption of other calcium-rich foods should become a habit from childhood. This idea has also been raised in previous literature where subjects have proposed that education concerning calcium-rich foods at school or by their parents could possibly enable their consumption to become a habitual practice into adulthood [20,43]. A recent study highlighted key gaps with respect to Nutrition and Food Sciences curriculum in Australian schools, such that it is considered to be insufficient and untranslatable for everyday practices [60]. Future interventions should create an environment where both children and adolescents receive education about calcium and its health-related outcomes. As suggested by previous studies, culture and traditions play an important role in shaping dietary practices, which cannot be overlooked [61]. The combination of positive parental influence and development of habits from early childhood are likely to result in a positive impact and a continuation of dietary habits in young adulthood.

Strengths and limitations

To our knowledge, this is the first study to report on enablers and barriers to calcium intake in Australia. The use of qualitative research is both an important strength and a limitation of this explorative study. Qualitative research allows us to understand not only the what, but also the how and why, which is important when examining at the beliefs and attitudes of young adults. Conversely, limitations of the use of focus groups may be that individuals felt insecure about sharing their thoughts and opinions or may have been pressured to conform their opinions to the rest of the group [27]. As with most studies, using a convenience sample of volunteers introduces self-selection bias, despite attempts to broaden the scope of participants who were recruited. Young adults are more likely to volunteer if they are health or nutrition conscious where females are over-represented. Another limitation is that most participants were enrolled in tertiary education. However, 56% of the Australian population have tertiary level qualifications: diploma, certificate or degree [62].

Conclusions and practical implications

The focus groups provided insight into perceived barriers and enablers to the consumption of calcium-rich foods, highlighting how capability, opportunity and motivation can impact behaviours with respect to the consumption of adequate dietary calcium in young adults. Although young adults were aware of the main health benefits of calcium in relation to bone health, a large gap in knowledge was identified regarding nondairy sources, health benefits in preventing disease, and recommended amounts. With regard to opportunity, cost concerns were raised for cheese, with milk being labelled as inexpensive and convenient. Young adults identified taste, family and cultural practices as motivators and also reflected on their reasons for low intake (i.e. having other priorities or labelling it as a 'future me' problem). This identifies the need for future nutrition interventions to emphasise the self-assessment of current calcium intake as a primary step towards reaching the recommended intake. Our findings highlight the need to develop an intervention providing information on social media from a credible source. An age-specific intervention with a focus on education could effectively provide young adults with knowledge to support their behaviour change. Given the role of parental influence and habit formation in childhood, interventions could also focus on promoting other forms of calcium from a younger age, allowing consumption to continue through to adulthood. The findings from the present study will be used to inform the development of a social media intervention for young adults. The intervention will focus on emphasising the existing enablers to calcium-rich foods and overcoming the barriers identified in our study.

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Conflict of interests, source of funding, and authorship

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AR and MAF developed the research question. AR and SC structured the focus groups. AR and SC contributed to conducting and recording of focus group sessions. SC completed by the data analysis. AR checked the data analysis. SC and AR were responsible for writing the first draft of the manuscript and all authors contributed to the preparation of the final manuscript submitted for publication.

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Chapter Six

Messaging for Interventions Aiming to Improve Calcium Intake in Young Adults—A Mixed Methods Study

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6.1 Publication details

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6.2 Author contribution

I Anika Rouf (the candidate) and MA-F contributed to the conception and design of the study. I conducted the research, analysed the data, and drafted the manuscript. MA-F contributed to interpretation of the results and editing of the manuscript. All authors have read and approved the final version of the manuscript.

6.3 Introduction to the chapter

Behaviour interventions are often designed to educate people on the consequence of a particular heath behaviour. However, interventionists aiming to educate individuals must consider framing as interventions have the potential to benefit by strategically using a particular style of message framing. It is not known what kind of messaging works best for young adults. My findings from Chapter Five shows that young adults lack knowledge of dairy and calcium and this may be a barrier that is associated with low intake. It is evident that future interventions should address this gap in knowledge but it is unclear what style and type of content is preferred by this population. This chapter aims to understand the preferred messaging of young adults which will inform our intervention development.

6.4 Abstract

Abstract: Social media channels are the preferred communication tools for many young adults and therefore may have applications in health promotion. The framing of messages is important, as an intervention must resonate with the target group. The aim of this study was to determine what type of messaging is preferred by young adults to improve their calcium intake. A cross-sectional web-based survey was conducted and young adults aged 18 to 25 years recruited. A 14-item survey collected information on the participants' demographics, ranking of text messages, mock Facebook posts with images, preferences related to type of posts they find personally relevant, and frequency and likelihood of engagement with posts and polls in social media. In addition, optional responses from participants about factors that motivate them to consume more calcium-rich foods were included and thematically analysed using NVivo. Eighty-one participants (17 males) completed the survey. No significant difference in ranking of the text messages and Facebook posts were found.

Participants indicated that recipe demonstrations (n = 71), cost-saving tips (n = 70), and information on recommended daily intake (n = 62) were personally relevant, while meal inspiration (n = 70), awareness-raising posts (n = 41), and messages about obtaining enough calcium from non-dairy sources (n = 38) would encourage them to eat more calcium-rich foods. The qualitative replies indicated the tone (in young adults' language) and length (short) of messages preferred, and the messaging they perceived would motivate young adults. In conclusion, short, aesthetically pleasing and personally relevant messages written in the language of young adults were recommended.

6.5 Introduction

Improvements in population nutrition have a pivotal role in the prevention of chronic disease. Despite large investments in preventative health campaigns [1], the diet of Australians remains a significant factor influencing non-communicable diseases [2]. Among the chronic diseases that have a nutritional component in their aetiology is osteoporosis, and attainment of peak bone mass during adolescence to young adulthood may be important for prevention [3,4]. Australian young adults are in need of an intervention to improve their currently sub-optimal calcium intakes [5]. However, young adults are a difficult-to-reach population with relatively low healthcare utilisation, which makes it difficult to disseminate information in this age group [6]. The Internet, social media, and smartphones are preferred communication and information channels for young adults [7]. The Internet has become a very popular medium for searching of health information [8,9]. However, large concerns remain about the credibility and reliability of information available online [10,11]. While young adults may be exposed to many types of health messages online, research shows they lack self-efficacy when it comes to practising these healthy dietary behaviours [12]. Interventions that aim to change an individual's dietary behaviour should consider message framing to enhance the

likelihood of uptake and resonance with the target population [13]. Previous research indicates that the way health messages are framed can affect the way it is perceived, which can vary depending on age of the message recipient [14,15].

For an intervention to be effective in changing behaviour, the messages should be motivating and be personally relevant to the individuals [16]. This idea is supported by the Elaboration Likelihood Model [17] which suggests that the effectiveness of an intervention can be enhanced by maximising personal relevance [18]. The frequency at which messages are delivered may also be important, as messages sent too often may result in loss of attention, and those sent too infrequently may result in a diluted impact. It is also important to include components that promote engagement with an intervention [19,20]. Thus, it is necessary to develop messaging that meets the needs of targeted individuals to increase motivation. The aim of this study was to conduct an online survey to identify messaging types preferred by young adults to improve their calcium intakes.

6.6 Materials and Methods

6.6.1. Study Design

A cross-sectional web-based survey was conducted to capture views of young adults aged 18 to 25 years. Materials and methods of the online survey were approved by the Human Research Ethics Committee at the University (HREC). The ethics approval number is 2018/079.

6.6.2 Survey Development

The 14-item survey included basic demographic information (age, gender, whether currently studying or working), and asked for scoring of five text messages written in different tones [21]. These included an authoritative tone, with a nutrition expert to explain

with scientific reasoning why a nutrition behaviour should be performed; empathetic, which explains you understand their difficulties and want to help; generation Y, that appeals to this generation and acts as a peer providing insights; solution-based, that provides tips and ideas for change; and substitution-based, that suggests how to swap one nutrition behaviour for another [21]. Five mock Facebook posts (with images) concerning breakfast were also shown to participants. All messages concerned the breakfast meal and encouraged intake of calcium-rich foods. This was created based on evidence illustrating the importance of breakfast for adequate calcium consumption [22] and our analyses of the most recent National Nutrition Survey showing the highest intakes of calcium at this meal [5]. Texts and posts were ranked by participants from 1 to 5, where a lower score indicates a greater motivator.

Additional questions were provided on the different types of information that might be personally relevant to change their eating habits, and were related to the relevance of educational posts on serving sizes and calcium requirements, health benefits, recipes and cost-saving tips for their food budget, and additional web-based resources. They were also asked about factors motivating them to eat more calcium-rich foods; whether they preferred images on every post; their views on the preferred frequency of new posts; the likelihood of them sharing Facebook posts (scale 1 to 5); and whether they would engage in on-line polls and competitions in an intervention.

Finally, participants were provided with the option to share any other comments or ideas they may have using free text. However, this was optional while all other questions were compulsory. The survey was offered online using REDCap [23] for a period of four months (March to June 2018).

6.6.3 Recruitment

Young adults aged 18 to 25 years who had not completed or were not currently undertaking a nutrition-related degree were eligible to participate. Modes of recruitment

included distributing flyers at university, face-to-face and over social media. Participants were provided with a website link to REDCap to complete the survey (Figure 6.1). The website link opened to screener questions where participants were able to check their eligibility to participate in the study. If participants were eligible, they were provided with the Participant Information Statement and a brief description of the study. On the next screen, participants were asked to provide consent and proceed to completing the survey questions. As an incentive, participants were offered the chance to win one of five $20 AUD gift vouchers for a department store.

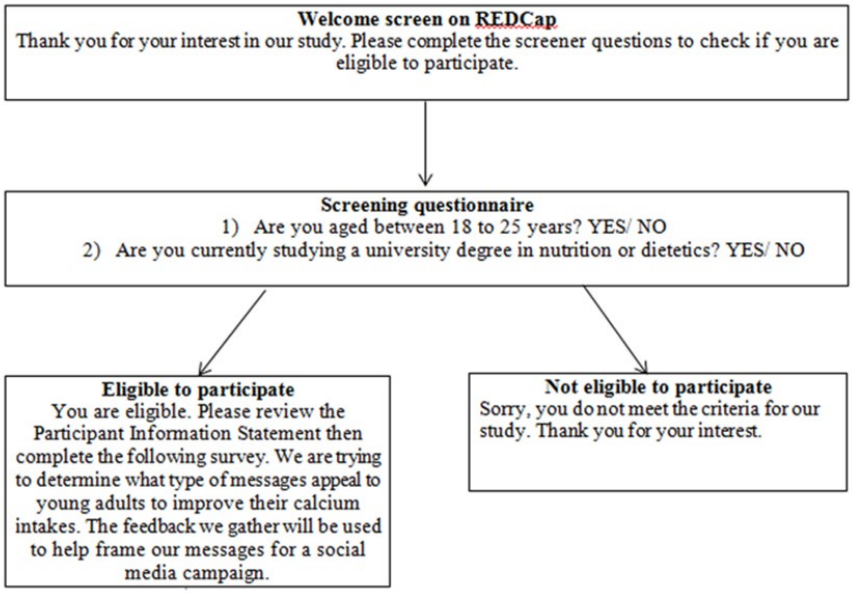

Figure 6.1. Survey recruitment process.

6.6.4 Data Analyses.

Responses from surveys were tabulated and mean scores for ranking calculated and analysis of variance (ANOVA) conducted to assess any differences in popularity of posts was performed using SPSS for Windows 22.0 software (IBM Corp. Released 20133 IBM SPSS Statistics for Windows, version 22.0 Armonk, NY: IBM Corp). The open-ended questions were analysed qualitatively using NVivo 11 (2015, version 11.0.0317, QSR International Pty

Ltd., Melbourne, Victoria, Australia). Descriptive coding was selected to summarise the comments made by respondents. This approach [24] involved a thorough reading of all comments to become familiar with the data. The next step was to generate initial codes to capture the main ideas. The themes were then reviewed, finalized, and named. Finally, representative quotes [25] were organized under each of these themes to accurately depict the voice of participants and ensure that the concepts remain close to participants' own words or terms.

6.7 Results

6.7.1 Sample Characteristics

The survey was attempted by 116 participants and completed by 81 respondents. Only the responses from participants who completed the survey were included in the analyses. The mean age of the participants was 21.91 ± 2.34 years (Table 6.1). The majority of the respondents were female (n = 64) and studying full-time (n = 57). A smaller proportion of the participants were working full-time (n = 16), studying part-time (n = 4), or other (n = 4). Category "other" included recent graduates looking for work and those currently working with plans to begin studies.

Table 6.1 Survey participant characteristics (n = 81).

Characteristics	*n*
Males	17
Age, years	
18–20	21
21–25	60
Occupation	
Full-time student	57
Part-time student	4
Working full-time	16
Other	4

6.7.2. Quantitative Analyses

Table 6.2 shows the mean ranking scores for the five different text messages. Table 6.3 shows mock Facebook posts with images where participants were asked to rank their preference in a similar manner. The mean scores for texts ranged from 2.7 to 3.3 and for the posts ranged from 2.6 to 3.2. No significant differences in scores were found ($F = 2.152$, $p = 0.074$ for texts; $F = 1.904$, $p = 0.109$ for posts). Direct comparisons of the text messages by tone is not possible because of small differences in content and images were varied in the Facebook posts.

Table 6.2 Participants rating of messages as the most motivating to increase calcium-rich food and the mean score (1 is the highest motivation and 5 is the lowest motivation possible).

Message	Tone of Voice	Mean Score
It is important to get your calcium every day as it can lower your risk of chronic diseases. If you are not meeting your recommendations, it is time to make to a change and start being a healthier you at breakfast!	Authoritative	3.3
We understand that it is hard for you to eat healthy when you have a very busy life, but planning your meals early will make it easier. You could start with planning your breakfast the night before with something as simple as yoghurt and muesli?	Empathetic	3.1
Plan your brekkie the night before and step up your brekkie game! Add some milk or yoghurt and you're good to go #brekkielikeaboss	Generation Y	2.8
Did you know that breakfast is an easy way to boost your calcium intake? Start your day by pouring some milk on your cereal or top some yoghurt on your muesli.	Solution-based	2.7
Being in a rush in the morning can often mean grabbing breakfast from outside. Why not start planning your breakfast the night before to save yourself from making unplanned purchases in the morning?	Substitution-based	3.0

Table 6.3 Participant rating for Mock Facebook post as the most motivating to increase calcium-rich foods and the mean score (1 is the highest motivation and 5 is the lowest motivation possible).

Mock Post Example	Mean Score
Research has shown that consuming breakfast is associated with positive health outcomes including improved cognitive function and memory. If you are not a breakfast eater, it is time to make a change and look after yourself! Why don't you start with this overnight chia pudding? Like this post if you want us to share the recipe. 	3.1
We know that it is difficult to wake up early for breakfast because sleep is so precious! And this is why we have created easy granola recipes like these so you can get the best of both worlds. Like this post if you want us to share the recipe. 	3.2
Need a sweet fix? We've got you covered with this delicious chocolate mousse. We have used ricotta and almonds here to bump up the calcium content. Like this post if you want us to share the recipe.	2.6

Craving a sweet dessert? Satisfy your craving with these cute pikelets that are calcium-rich and delicious. Like this post if you want us to share the recipe.

3.1

Instead of purchasing pancakes from outside, why don't you make some on your own? These calcium-rich ricotta pancakes will curb your sweet craving and keep you feeling satisfied! Like this post if you want us to share the recipe.

3.0

6.7.3 Personal Relevance

Respondents were allowed to choose more than one answer when indicating their personal relevance. Young adults chose recipe demonstrations and meal ideas as the most preferred types of posts (n = 71), closely followed by cost- or money-saving tips (n = 70). This was followed by a post on recommended daily intake as they were not sure how much calcium they needed to consume every day (n = 62), and an educational post on serving size (n = 56). Posts regarding the health benefits of calcium and those that provided links to additional resources (i.e. current research, the dietary guidelines and other credible sources of information) were of less relevance to the respondents (n = 38; n = 45 respectively). When asked what would motivate them to eat more calcium foods, participants once again indicated that meal inspiration posts including recipe ideas and pictures (n = 70) would be most helpful. Awareness raising stating health benefits and the risks of not consuming enough (n = 41) or posts educating on non-dairy or vegan sources of calcium were less popular (n = 41; n = 38 respectively). Almost all participants indicated their preference for seeing an image with every post (n = 76).

In terms of frequency of posts, the most common response was a few times a week (n = 33); but 10 participants said daily. Using a Likert scale, the majority of participants indicated their reluctance to tag, comment and share posts about calcium with their own Facebook friends (n = 52). The average score was 2.15 ± 1.0, with 1 ranked as “not likely” and 5 ranked as “highly likely”. In regard to engaging in on-line activities, over half were happy to use a voting poll (n = 46). A majority of participants expressed reluctance to share their food-related photo on a public social media page.

6.7.4 Thematic Analysis of Open Comments

In total, 22 participants responded to the optional free text box at the end of the survey. The majority of the respondents were females (n = 19) and were studying full-time (n = 17). All responses from participants were thematically analysed which broadly related to their preferences for an intervention, as well as motivators to consume calcium-rich foods.

6.7.5 Tone and Text

Several participants suggested posts should be kept short and sharp at the same time, "*Short and sweet social media posts with good pictures reel me in every time*"; "*I tend to click for the recipe based on whether it looks delicious and if the ingredients seem healthy*". One participant indicated that some of the sample posts "*were too long and I struggled to get to the end of it*". The importance of aesthetics was highlighted by multiple participants as "*good quality photos really make it or break it for me*". One participant indicated using pictures and serving sizes to convey the message, "*posts about food-swaps where a common food item can easily be swapped for a higher calcium version*".

A few participants indicated that paternalistic messages should be avoided, "*I think people might disengage a bit if they see a message as paternalistic…"*. Participants suggested that hashtags should be used with caution, as illustrated by "*the hyperactive peppy hashtag thing is kind of patronising; I really haven't heard or seen anyone of any age group talk like that*". It was suggested that posts should be phrased appropriately, as illustrated by "*I think the most important way to get young people's attention is to hire young people to write the posts—they know how to talk to our generation over the Internet the best, e.g. in a way that doesn't sound condescending or boring".* It was also proposed that the messages should be made memorable, "*I think the best way to advertise is to make an ad funny and memorable. Maybe with a catchy slogan or something that people will never forget*".

6.7.6 Personal Relevance

In terms of personal preferences for text, participants expressed their desire to make any health messages relevant to the age group. Participants acknowledged the pressure young adults face while juggling work and study commitments and highlighted the need for including convenience options for their busy lifestyle, "*It is important to tell young adults how to consume calcium rich foods in a busy lifestyle*". Suggested options included "*on-the-go snacks that look appealing and foods that do not show all the health benefits on face (i.e., salads)*".

Some participants highlighted not being able to see calcium intake as a priority, as illustrated by "*I reckon just giving people an easy avenue into increasing calcium intake and a reason to care (immediate benefits like being more sharp and strong as well as the long-term ones) will do the trick*". It was also suggested that health messages must be made relevant to the age group, as "*stuff happening decades from now is bad but elicits less of an urgency and personal response than stuff happening in our near future or that directly impacts other goals (e.g., full-time employment, sporting achievements, academic success etc.)".*

Participants acknowledged the challenges that young adults face which makes it difficult to put diet as a priority, as illustrated by, "*they aren't stupid. If they're not getting enough calcium, it probably just skipped their minds because most people are really busy juggling family and friends and life in general, not because they think it's uncool*".

6.7.7 Motivators

The most commonly reported motivator was found to be taste, "*I tend to click for the recipe based on whether it looks delicious and if the ingredients seem healthy*". A few participants highlighted the importance of cost as a motivator. One participant explained that money saving tips could act as a motivator, "*as a uni student, I find that anything to do with*

money saving really gets my attention". It was indicated that the behaviour change should seem attainable, as illustrated by, "*I think above all, getting the proper calcium intake needs to seem easy to achieve. I already know that I don't eat well but changing my habits requires changing my mindset*".

Two participants suggested using 'freebies' and providing more examples of calcium-rich foods to get the attention of young adults, "*I think you guys should give more examples about easy get food with abundant calcium, especially, with good taste will be better, or provide some menu, or freebie on the street to us*". Further suggestions for motivation included having more social media posts on the risks of inadequate calcium intake, as demonstrated by, "*increasing understanding of how having an adequate intake of calcium can affect more than just bone healthy; increasing understanding of all the benefits of calcium and more information on calcium sources*". It was indicated that the negative effects of low consumption should be communicated clearly, as shown by "*makes posts that explain the detrimental health effects of not taking in calcium and at the end provide an easy nutritional recipe that can help boost it*".

6.8 Discussion

To our knowledge, this is the first study to examine aspects of messaging for improving calcium intake in young adults. All text messages and messages with posts scored similarly. Relevance to the age group is obviously needed and recipes and tips keenly sort. While young adults like the idea of social media posts, they are not keen to engage in sharing posts with other members in a research setting and would be unlikely to share the Facebook intervention posts with a friend.

A previous study measuring public engagement of the National Cancer Institute Facebook page reported that posts with photos received significantly more likes, comments

and shares [26]. Visual content on social media can grab the attention of readers and portray information more efficiently than plain text messages [27]. For example, photos on Facebook will typically generate 53% more likes compared to a post containing text only [28]. A few respondents commented on picture quality as the most important factor, which is comparable to an online survey conducted worldwide where production quality was rated as the number one factor [29]. Moreover, the preference for meal inspiration posts and recipe demonstrations indicate the great potential of video technology in educating young adults. Mayer's cognitive theory of digital learning explains that viewers can only process a limited amount of information at one time as visual and auditory information are processed via different pathways [30]. However, as video technology comes with pause and rewind options, it allows the learners to process more information [31]. A previous study investigating vegetable intake in Australian young adults reports similar findings, where food pictures and recipe ideas were ranked as highly preferred while awareness raising posts received a lower ranking [32].

To make the messaging relevant to young adults, we need to understand that they lead busy lifestyles and want suggestions for eating more calcium-rich foods to provide quick and easy options without the need to invest large amounts of time and energy into cooking [33]. The messages must also contain something of relevance for the present time in their lives rather than the threat of something in the distant future [34]. The scoring of the text messages did not differ by the tone; however, direct comparisons are not possible because of confounding by content and length. Previous research has found a preference for GenY or authoritative tone [21,32]. Our qualitative research here did indicate that the language of young adults was preferred. Gender-specific messaging may be particularly helpful [35,36]; as research suggests that young males are motivated by messages relating to physique [32,37,38]. In contrast, young females are motivated by messages that improve their self-

confidence [39,40]. There was acceptance of messaging about health consequences, raising awareness and increasing knowledge, and explaining why it is important to take action, which is consistent with literature [41].

Regarding the types of messages that motivate participants to engage and change behaviour, the appeal, taste and cost of suggested foods and recipes is important. Our comments from participants showed that taste was an important factor influencing food choice which is similar to other studies conducted with young adults [42,43]. Some participants indicated that cost influenced their food choices, which is also consistent with earlier qualitative work with young people [21,43–46]. The majority of respondents were reluctant to share personal content with strangers, as has been reported previously in an Australian study involving healthy young adults [32]. Similarly, studies conducted with young adults with diabetes or common mental health disorders reveal that many choose not to disclose health experiences to avoid potential negative implications for identity construction [47]. In particular, Facebook has been identified as a space for constructing personal and group identity [48–51] which means that posting or "liking" content can mirror offline social interactions and be seen as performing to identity [52]. The users are concerned about how audiences might view their disclosure and even the seemingly innocuous act of "liking" pages can affect their management of identity [47].

6.8.1 Study Limitations and Future Implications

The strengths of this study include the large sample size which has allowed for the generation of quantitative and qualitative data. While most of our respondents included 18 to 25-year-olds enrolled in tertiary education, some were also employed in the workforce. A limitation of the study was the underrepresentation of young males, as they were far from reaching equal proportions. However, this is similar to other Australian research that has found it more difficult to recruit men into population studies [53]. To reduce the burden on

the respondents, only one set of messages and one set of Facebook posts were tested. No conclusions about the preferred tone of messages can be made because of confounding by length of messages as the qualitative research revealed length matters and variations in content is another confounder; using only one set of messages limits the generalizability of the scoring; the posts made with the images are not directly comparable because different foods were depicted each time and this confounds rankings. The qualitative comments provided insights on the preferred tone and type of messages and showed that images are well received. The findings of this research were part of formative evaluation for an intervention aimed to improve calcium intake in Australian young adults. Therefore, caution should be exercised when interpreting these findings for other groups, especially those from other countries or with different cultures.

6.8.2 Conclusions

Personal relevance of messages and targeting motivations, as well as tone, length and aesthetics must be considered in developing social media based interventions. The findings captured in this survey together with findings of previous research will be used to refine the design of a Facebook intervention to improve calcium intake in young adults.

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6.10 Conclusion to Chapter

The formative research conducted in this chapter provided further insights into the needs and wants of young adults for an intervention. The preferences obtained from participants included qualitative and quantitative measures. Recipe demonstrations and meal ideas were the most preferred type of posts which is consistent with findings from the previous chapter. This was followed by posts on recommended dietary intakes and information on serving size which is likely to be resulting from the lack of knowledge identified in Chapter Five. A high level of reluctance was noted in regards to sharing content with others. The need to provide a social media program in which participants feel comfortable and engaged to post their content was apparent. The findings from this chapter will guide the refinement of program material for a future intervention. The next chapter will detail the step by step process that was used to develop the CAN-DO program.

Appendix 6

Appendix 6.1 Ethical approval for an online cross-sectional survey

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
Human Research Ethics Committee

Monday, 5 March 2018

Prof Margaret Allman-Farinelli
School of Life and Environmental Sciences (SOLES); Faculty of Science
Email: margaret.allman-farinelli@sydney.edu.au

Dear Margaret

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

After consideration of your response to the comments raised your project has been approved.

Approval is granted for a period of four years from **05 March 2018** to **05 March 2022**

Project title: **Testing the preferred tone of messages for an intervention aimed to improve calcium intake in young adults**

Project no.: **2018/079**

First Annual Report due: **05 March 2019**

Authorised Personnel: **Allman-Farinelli Margaret; Rouf Anika;**

Documents Approved:

Date Uploaded	Version number	Document Name
28/02/2018	Version 1	Online survey_final copy
28/02/2018	Version 2	PIS_final copy
28/02/2018	Version 2	Recruitment poster revised
22/01/2018	Version 1	REDCap survey
22/01/2018	Version 1	Short recruitment post
22/01/2018	Version 1	Face-to-face recruitment script

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).

Research Integrity & Ethics Administration
Level 2, Margaret Telfer Building (K07)
The University of Sydney
NSW 2006 Australia

T +61 2 9036 9161
E human.ethics@sydney.edu.au
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ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely

Associate Professor Stephen Assinder
Chair
Human Research Ethics Committee (HREC 1)

The University of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007) and the NHMRC's Australian Code for the Responsible Conduct of Research (2007).

Appendix 6.2 Recruitment poster used to invite young adults to take part in the survey

Appendix 6.3 Participation Information Statement (a PDF was attached on REDCap)

THE UNIVERSITY OF SYDNEY

Discipline of Nutrition and Dietetics
School of Life and Environmental Sciences
Faculty of Science

ABN 15 211 513 464

Margaret Allman-Farinelli
Professor of Dietetics

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Testing the preferred tone of messages for an intervention aimed to improve calcium intake in young adults

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in an online survey that will involve answering a few questions on the type of messaging you prefer to see on social media. We are trying to determine the type of messages that appeal to young adults to improve their calcium intakes. This study will help to identify what kind of messaging is preferred by young adults and will be used to frame our social media campaign.

You have been invited to participate in this study because you meet the demographics required for this study. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving your consent to take part in this study you are telling us that you:
- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

You will be able to save a copy of the Participant Information Statement. If you wish to keep a copy for your records, make sure to save this PDF on your computer.

(2) Who is running the study?

The study is being carried out by the following researchers:
- Margaret Allman-Farinelli, Professor of Dietetics
- Anika Rouf, PhD Candidate

(3) What will the study involve for me?

You will be required to complete a short online survey which can be completed using a smartphone device or computer.

(4) How much of my time will the study take?

The online survey will take approximately 10 to 15 minutes to complete.

(5) Who can take part in the study?

This study requires participants aged between 18-25 years old. Participants who have completed a nutrition course or those currently undertaking a nutrition course will be excluded as their nutrition knowledge would be more than that of an average young adult.

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at The University of Sydney. You are allowed to withdraw in the middle of completing the survey if you are not comfortable answering the questions.

(7) Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study. Participation in this study should involve no physical or mental discomfort. If, however, you should find any questions to be offensive or invasive, you are free to withdraw from answering the survey questions.

(8) Are there any benefits associated with being in the study?

We cannot guarantee that you will receive any direct benefits from being in the study. You may gain some health information from viewing the social media posts. After the completion of the online survey, you will be eligible to enter a draw to win one of five Coles and Myer vouchers (worth $20 each). However, this is optional.

(9) What will happen to information about me that is collected during the study?

All data collected in this study will be stored confidentially. Only members of the research team will have access to identified data. In our report, we may use responses from the survey to help illustrate points being made; however, you will not be identifiable from these quotes.

Your information will be stored securely and your identity/information will be kept strictly confidential, except as required by law. Study findings may be published, but you will not be individually identifiable in these publications.

By providing your consent, you are agreeing to us collecting personal information, such as age and gender, about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

(10) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?

When you have read this information, Anika Rouf will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact

(12) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell us that you wish to receive feedback by emailing Anika (arou9270@uni.sydney.edu.au). This feedback will be in the form of a one page summary and can be sent after the study is finished.

(13) What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney *[INSERT* protocol number once approval is obtained*]*. As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** human.ethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

This information sheet is for you to keep

Appendix 6.4 Screenshots of the survey conducted on young adults using REDCap

Thank you for your interest in our study.
Please complete the screener questions to check if you are eligible to participate.

1. Are you aged between 18 to 25 years? * must provide value	○ Yes ○ No	reset
2. Are you currently studying or have studied a course that includes nutrition or dietetics? * must provide value	○ Yes ○ No	reset
Sorry, you do not meet the criteria for our study because you are not within the age of research interest or have studied or currently studying a nutrition-related degree. Thank you for your interest.		
You are eligible. Please review the Participant Information Statement then complete the following survey. We are trying to determine what type of messages appeal to young adults to improve their calcium intakes. The feedback we gather will be used to help frame our messages for a social media campaign. Attachment: Participant_Information_Statement.pdf (0.13 MB)		
Consent questions **• I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.** **• I have read the Participant Information Statement** **• I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of Sydney now or in the future.** **• I understand that I can withdraw from the study at any time.** **• I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.** * must provide value	○ Yes ○ No	reset
Please proceed to the survey questions on the next page.		

1. Please enter your age.
* must provide value

2. What is your gender?
* must provide value

- Male
- Female

reset

3. Are you currently?
* must provide value

- a. Studying full-time
- b. Studying part-time
- c. Working full-time
- d. Other

reset

* must provide value

Please tell us more about your current situation.

4. Which of the following posts would be most motivating to increase your calcium intake? Please RANK the following posts in your order of appeal (1 ranked as most appealing and 5 ranked as least appealing)

(One selection allowed per column)	1	2	3	4	5
It is important to get your calcium everyday as it can lower your risk of chronic diseases. If you are not meeting your recommendations, it is time to make to a change and start being a healthier you at breakfast! * must provide value					
We understand that it is hard for you to eat healthy when you have a very busy life, but planning your meals early will make it easier. You could start with planning your breakfast the night before with something as simple as yoghurt and muesli. * must provide value					
Plan your brekkie the night before and step up your brekkie game! Add some milk or yoghurt and you're good to go #brekkielikeaboss * must provide value					
Did you know that breakfast is an easy way to boost your calcium intake? Start your day by pouring some milk on your cereal or top some yoghurt on your muesli. * must provide value					
Being in a rush in the morning can often mean grabbing breakfast from outside. Why not start planning your breakfast the night before to save yourself from making unplanned purchases in the morning? * must provide value					

reset

5. Which of the following posts would be most motivating to increase your calcium intake? Please rank the following posts in your order of appeal.

Option A
Research has shown that consuming breakfast is associated with positive health outcomes including improved cognitive function and memory. If you are not a breakfast eater, it is time to make a change and look after yourself! Why don't you start with this overnight chia pudding? Like this post if you want us to share the recipe.

Option B
We know that it is difficult to wake up early for breakfast because sleep is so precious! And this is why we have created easy granola recipes like these so you can get the best of both worlds. Like this post if you want us to share the recipe.

Option C
Need a sweet fix? We've got you covered with this delicious chocolate mousse. We have used ricotta and almonds here to bump up the calcium content. Like this post if you want us to share the recipe.

Option D
Craving a sweet dessert? Satisfy your craving with these cute pikelets that are calcium-rich and delicious. Like this post if you want us to share the recipe.

Option E
Instead of purchasing pancakes from outside, why don't you make some on your own? These calcium-rich ricotta pancakes will curb your sweet craving and keep you feeling satisfied! Like this post if you want us to share the recipe.

Please rank the following posts in your order of appeal (1 ranked as most appealing and 5 ranked as least appealing)

(One selection allowed per column)	1	2	3	4	5	
Option A * must provide value	○	○	○	○	○	reset
Option B * must provide value	○	○	○	○	○	reset
Option C * must provide value	○	○	○	○	○	reset
Option D * must provide value	○	○	○	○	○	reset
Option E * must provide value	○	○	○	○	○	reset

6. Which of the following posts do you find personally relevant? (Can select more than one option)

	Yes, relevant for me.	No, not relevant for me.
Educational posts on serving size because I am not sure what a serve is. * must provide value	○	○
Recommended daily intake because I am not sure how much calcium we need to have every day. * must provide value	○	○
Health benefits of calcium intake because I am not aware of the benefits calcium has on our health. * must provide value	○	○
Recipe demonstrations and meal ideas because I am time-poor and would like to get some inspiration for my cooking. * must provide value	○	○
Cost or money saving tips because healthy eating can be expensive so I'd like to know how to save money. * must provide value	○	○
Links to additional resources so I can find out more in my spare time. These sources can include current research, dietary guidelines, news articles etc. * must provide value	○	○

7. What kind of posts would encourage you eat more calcium-rich foods? Select all that apply.
* must provide value

- ☐ a. Meal inspiration posts including recipe ideas and pictures
- ☐ b. Awareness raising posts stating health benefits or risks of not consuming enough
- ☐ c. National statistics on inadequate intake of calcium
- ☐ d. How to get enough calcium from vegan or non-dairy sources

8. Do you prefer to see an image with every post?
* must provide value

- ○ a. Yes, images are great and draw my attention to the post
- ○ b. No, images are distracting and can take the attention away from the main message

9. How frequently would you like to see posts online?
* must provide value

- ○ a. A few times a day
- ○ b. Once a day
- ○ c. A few times a week
- ○ d. Once a week

	1. Very unlikely	2. Unlikely	3. Neutral	4. Likely	5. Very likely
10. On a scale of 1 to 5, how likely would you be to tag, comment and share posts about calcium with your own Facebook friends?	○	○	○	○	○

11. Would you be interested in participating in voting polls? This can mean asking the group what they would like to see more or less of. Polls can be a great way for us to learn about your preferences and help us tailor the content to your needs.
* must provide value

- ○ a. Yes I would be happy to vote.
- ○ b. No, I would not participate and would prefer to read posts only.
- ○ c. No, I would not participate because I find it time consuming.

12. Would you be interested in sharing your own food-related content on social media? This may include a photo of a dish you've cooked from one of our shared recipes.

- ○ a. Yes, I would be happy to share my content.
- ○ b. Yes, I would consider sharing my content only if there was a reward or an incentive of some sort.
- ○ c. No, this approach doesn't work for me.

13. Would you be interested in participating in a shout out contest where food related content that you share is featured on our social media page?
* must provide value

- ○ a. Yes, I would be happy to share my content.
- ○ b. Yes, I would be happy to share my content
- ○ c. No, this approach doesn't work for me

14. Is there anything else that you'd like to tell us? This is your last chance to tell us what you think would motivate young adults like you to eat more calcium rich foods. Please feel free to share any other ideas you might have!

Expand

Thank you completing the survey. You are now eligible to enter a draw to win 1 of 5 Coles and Myer Vouchers. Please leave us your email address below if you would like to take part in the draw (optional). We will notify the winners via email.

Please make sure you have typed your email address correctly.

Appendix 6.5

Publication resulting from Chapter Six, *Nutrients*, 2018, 10 (11): 1673
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(See next page)

nutrients

MDPI

Article

Messaging for Interventions Aiming to Improve Calcium Intake in Young Adults—A Mixed Methods Study

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Abstract: Social media channels are the preferred communication tools for many young adults and therefore may have applications in health promotion. The framing of messages is important, as an intervention must resonate with the target group. The aim of this study was to determine what type of messaging is preferred by young adults to improve their calcium intake. A cross-sectional web-based survey was conducted and young adults aged 18 to 25 years recruited. A 14-item survey collected information on the participants' demographics, ranking of text messages, mock Facebook posts with images, preferences related to type of posts they find personally relevant, and frequency and likelihood of engagement with posts and polls in social media. In addition, optional responses from participants about factors that motivate them to consume more calcium-rich foods were included and thematically analysed using NVivo. Eighty-one participants (17 males) completed the survey. No significant difference in ranking of the text messages and Facebook posts were found. Participants indicated that recipe demonstrations (n = 71), cost-saving tips (n = 70), and information on recommended daily intake (n = 62) were personally relevant, while meal inspiration (n = 70), awareness-raising posts (n = 41), and messages about obtaining enough calcium from non-dairy sources (n = 38) would encourage them to eat more calcium-rich foods. The qualitative replies indicated the tone (in young adults' language) and length (short) of messages preferred, and the messaging they perceived would motivate young adults. In conclusion, short, aesthetically pleasing and personally relevant messages written in the language of young adults were recommended.

Keywords: young adults; calcium; health promotion; social media; public health

1. Introduction

Improvements in population nutrition have a pivotal role in the prevention of chronic disease. Despite large investments in preventative health campaigns [1], the diet of Australians remains a significant factor influencing non-communicable diseases [2]. Among the chronic diseases that have a nutritional component in their aetiology is osteoporosis, and attainment of peak bone mass during adolescence to young adulthood may be important for prevention [3,4]. Australian young adults are in need of an intervention to improve their currently sub-optimal calcium intakes [5]. However, young adults are a difficult-to-reach population with relatively low healthcare utilisation, which makes it difficult to disseminate information in this age group [6]. The Internet, social media, and smartphones are preferred communication and information channels for young adults [7]. The Internet has become a very popular medium for searching of health information [8,9]. However, large concerns remain about the credibility and reliability of information available online [10,11]. While young adults may be exposed to many types of health messages online, research shows they lack self-efficacy when it comes

to practising these healthy dietary behaviours [12]. Interventions that aim to change an individual's dietary behaviour should consider message framing to enhance the likelihood of uptake and resonance with the target population [13]. Previous research indicates that the way health messages are framed can affect the way it is perceived, which can vary depending on age of the message recipient [14,15]. For an intervention to be effective in changing behaviour, the messages should be motivating and be personally relevant to the individuals [16]. This idea is supported by the Elaboration Likelihood Model [17] which suggests that the effectiveness of an intervention can be enhanced by maximising personal relevance [18]. The frequency at which messages are delivered may also be important, as messages sent too often may result in loss of attention, and those sent too infrequently may result in a diluted impact. It is also important to include components that promote engagement with an intervention [19,20]. Thus, it is necessary to develop messaging that meets the needs of targeted individuals to increase motivation. The aim of this study was to conduct an online survey to identify messaging types preferred by young adults to improve their calcium intakes.

2. Materials and Methods

2.1. Study Design

A cross-sectional web-based survey was conducted to capture views of young adults aged 18 to 25 years. Materials and methods of the online survey were approved by the Human Research Ethics Committee at the University (HREC). The ethics approval number is 2018/079.

2.2. Survey Development

The 14-item survey included basic demographic information (age, gender, whether currently studying or working), and asked for scoring of five text messages written in different tones [21]. These included an authoritative tone, with a nutrition expert to explain with scientific reasoning why a nutrition behaviour should be performed; empathetic, which explains you understand their difficulties and want to help; generation Y, that appeals to this generation and acts as a peer providing insights; solution-based, that provides tips and ideas for change; and substitution-based, that suggests how to swap one nutrition behaviour for another [21]. Five mock Facebook posts (with images) concerning breakfast were also shown to participants. All messages concerned the breakfast meal and encouraged intake of calcium-rich foods. This was created based on evidence illustrating the importance of breakfast for adequate calcium consumption [22] and our analyses of the most recent National Nutrition Survey showing the highest intakes of calcium at this meal [5]. Texts and posts were ranked by participants from 1 to 5, where a lower score indicates a greater motivator.

Additional questions were provided on the different types of information that might be personally relevant to change their eating habits, and were related to the relevance of educational posts on serving sizes and calcium requirements, health benefits, recipes and cost-saving tips for their food budget, and additional web-based resources. They were also asked about factors motivating them to eat more calcium-rich foods; whether they preferred images on every post; their views on the preferred frequency of new posts; the likelihood of them sharing Facebook posts (scale 1 to 5); and whether they would engage in on-line polls and competitions in an intervention.

Finally, participants were provided with the option to share any other comments or ideas they may have using free text. However, this was optional while all other questions were compulsory. The survey was offered online using REDCap (Vanderbilt University, TN, USA) [23] for a period of four months (March to June 2018).

2.3. Recruitment

Young adults aged 18 to 25 years who had not completed or were not currently undertaking a nutrition-related degree were eligible to participate. Modes of recruitment included distributing flyers at university, face-to-face and over social media. Participants were provided with a website

link to REDCap to complete the survey (Figure 1). The website link opened to screener questions where participants were able to check their eligibility to participate in the study. If participants were eligible, they were provided with the Participant Information Statement and a brief description of the study. On the next screen, participants were asked to provide consent and proceed to completing the survey questions. As an incentive, participants were offered the chance to win one of five $20 AUD gift vouchers for a department store.

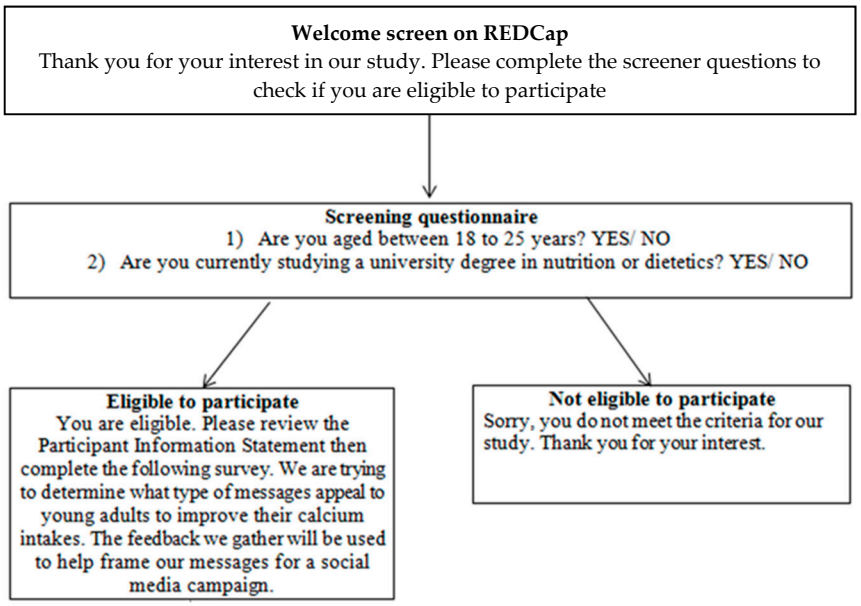

Figure 1. Survey recruitment process.

2.4. Data Analyses.

Responses from surveys were tabulated and mean scores for ranking calculated and analysis of variance (ANOVA) conducted to assess any differences in popularity of posts was performed using SPSS for Windows 22.0 software (IBM Corp. Released 20133 IBM SPSS Statistics for Windows, version 22.0 Armonk, NY: IBM Corp). The open-ended questions were analysed qualitatively using NVivo 11 (2015, version 11.0.0317, QSR International Pty Ltd., Melbourne, Victoria, Australia). Descriptive coding was selected to summarise the comments made by respondents. This approach [24] involved a thorough reading of all comments to become familiar with the data. The next step was to generate initial codes to capture the main ideas. The themes were then reviewed, finalized, and named. Finally, representative quotes [25] were organized under each of these themes to accurately depict the voice of participants and ensure that the concepts remain close to participants' own words or terms.

3. Results

3.1. Sample Characteristics

The survey was attempted by 116 participants and completed by 81 respondents. Only the responses from participants who completed the survey were included in the analyses. The mean age of the participants was 21.91 $\pm$ 2.34 years (Table 1). The majority of the respondents were female (n = 64) and studying full-time (n = 57). A smaller proportion of the participants were working full-time (n = 16), studying part-time (n = 4), or other (n = 4). Category "other" included recent graduates looking for work and those currently working with plans to begin studies.

Table 1. Survey participant characteristics (n = 81).

Characteristics	*n*
Males	17
Age, years	
18–20	21
21–25	60
Occupation	
Full-time student	57
Part-time student	4
Working full-time	16
Other	4

3.2. Quantitative Analyses

Table 2 shows the mean ranking scores for the five different text messages. Table 3 shows mock Facebook posts with images where participants were asked to rank their preference in a similar manner. The mean scores for texts ranged from 2.7 to 3.3 and for the posts ranged from 2.6 to 3.2. No significant differences in scores were found (F = 2.152, p = 0.074 for texts; F = 1.904, p = 0.109 for posts). Direct comparisons of the text messages by tone is not possible because of small differences in content and images were varied in the Facebook posts.

Table 2. Participants rating of messages as the most motivating to increase calcium-rich food and the mean score (1 is the highest motivation and 5 is the lowest motivation possible).

Message	Tone of Voice	Mean Score
It is important to get your calcium every day as it can lower your risk of chronic diseases. If you are not meeting your recommendations, it is time to make to a change and start being a healthier you at breakfast!	Authoritative	3.3
We understand that it is hard for you to eat healthy when you have a very busy life, but planning your meals early will make it easier. You could start with planning your breakfast the night before with something as simple as yoghurt and muesli?	Empathetic	3.1
Plan your brekkie the night before and step up your brekkie game! Add some milk or yoghurt and you're good to go #brekkielikeaboss	Generation Y	2.8
Did you know that breakfast is an easy way to boost your calcium intake? Start your day by pouring some milk on your cereal or top some yoghurt on your muesli.	Solution-based	2.7
Being in a rush in the morning can often mean grabbing breakfast from outside. Why not start planning your breakfast the night before to save yourself from making unplanned purchases in the morning?	Substitution-based	3.0

Table 3. Number of participants rating Mock Facebook post as the most motivating to increase calcium-rich foods and the mean score (1 is the highest motivation and 5 is the lowest motivation possible).

Mock Post Example	Mean Score
Research has shown that consuming breakfast is associated with positive health outcomes including improved cognitive function and memory. If you are not a breakfast eater, it is time to make a change and look after yourself! Why don't you start with this overnight chia pudding? Like this post if you want us to share the recipe. 	3.1
We know that it is difficult to wake up early for breakfast because sleep is so precious! And this is why we have created easy granola recipes like these so you can get the best of both worlds. Like this post if you want us to share the recipe. 	3.2
Need a sweet fix? We've got you covered with this delicious chocolate mousse. We have used ricotta and almonds here to bump up the calcium content. Like this post if you want us to share the recipe. 	2.6

Table 3. *Cont.*

Mock Post Example	Mean Score
Craving a sweet dessert? Satisfy your craving with these cute pikelets that are calcium-rich and delicious. Like this post if you want us to share the recipe. 	3.1
Instead of purchasing pancakes from outside, why don't you make some on your own? These calcium-rich ricotta pancakes will curb your sweet craving and keep you feeling satisfied! Like this post if you want us to share the recipe. 	3.0

3.3. Personal Relevance

Respondents were allowed to choose more than one answer when indicating their personal relevance. Young adults chose recipe demonstrations and meal ideas as the most preferred types of posts (n = 71), closely followed by cost- or money-saving tips (n = 70). This was followed by a post on recommended daily intake as they were not sure how much calcium they needed to consume every day (n = 62), and an educational post on serving size (n = 56). Posts regarding the health benefits of calcium and those that provided links to additional resources (i.e., current research, the dietary guidelines and other credible sources of information) were of less relevance to the respondents (n = 38; n = 45 respectively). When asked what would motivate them to eat more calcium foods, participants once again indicated that meal inspiration posts including recipe ideas and pictures (n = 70) would be most helpful. Awareness raising stating health benefits and the risks of not consuming enough (n = 41) or posts educating on non-dairy or vegan sources of calcium were less popular (n = 41; n = 38 respectively). Almost all participants indicated their preference for seeing an image with every post (n = 76).

In terms of frequency of posts, the most common response was a few times a week (n = 33); but 10 participants said daily. Using a Likert scale, the majority of participants indicated their reluctance to

tag, comment and share posts about calcium with their own Facebook friends (n = 52). The average score was 2.15 ± 1.0, with 1 ranked as "not likely" and 5 ranked as "highly likely". In regard to engaging in on-line activities, over half were happy to use a voting poll (n = 46). A majority of participants expressed reluctance to share their food-related photo on a public social media page.

3.4. Thematic Analysis of Open Comments

In total, 22 participants responded to the optional free text box at the end of the survey. The majority of the respondents were females (n = 19) and were studying full-time (n = 17). All responses from participants were thematically analysed which broadly related to their preferences for an intervention, as well as motivators to consume calcium-rich foods.

3.4.1. Tone and Text

Several participants suggested posts should be kept short and sharp at the same time, "*Short and sweet social media posts with good pictures reel me in every time*"; "*I tend to click for the recipe based on whether it looks delicious and if the ingredients seem healthy*". One participant indicated that some of the sample posts "*were too long and I struggled to get to the end of it*". The importance of aesthetics was highlighted by multiple participants as "*good quality photos really make it or break it for me*". One participant indicated using pictures and serving sizes to convey the message, "*posts about food-swaps where a common food item can easily be swapped for a higher calcium version*".

A few participants indicated that paternalistic messages should be avoided, "*I think people might disengage a bit if they see a message as paternalistic . . . "*. Participants suggested that hashtags should be used with caution, as illustrated by "*the hyperactive peppy hashtag thing is kind of patronising; I really haven't heard or seen anyone of any age group talk like that*". It was suggested that posts should be phrased appropriately, as illustrated by "*I think the most important way to get young people's attention is to hire young people to write the posts—they know how to talk to our generation over the Internet the best, e.g., in a way that doesn't sound condescending or boring".* It was also proposed that the messages should be made memorable, "*I think the best way to advertise is to make an ad funny and memorable. Maybe with a catchy slogan or something that people will never forget*".

3.4.2. Personal Relevance

In terms of personal preferences for text, participants expressed their desire to make any health messages relevant to the age group. Participants acknowledged the pressure young adults face while juggling work and study commitments and highlighted the need for including convenience options for their busy lifestyle, "*It is important to tell young adults how to consume calcium rich foods in a busy lifestyle*". Suggested options included "*on-the-go snacks that look appealing and foods that do not show all the health benefits on face (i.e., salads)*".

Some participants highlighted not being able to see calcium intake as a priority, as illustrated by "*I reckon just giving people an easy avenue into increasing calcium intake and a reason to care (immediate benefits like being more sharp and strong as well as the long-term ones) will do the trick*". It was also suggested that health messages must be made relevant to the age group, as "*stuff happening decades from now is bad but elicits less of an urgency and personal response than stuff happening in our near future or that directly impacts other goals (e.g., full-time employment, sporting achievements, academic success etc.)*".

Participants acknowledged the challenges that young adults face which makes it difficult to put diet as a priority, as illustrated by, "*they aren't stupid. If they're not getting enough calcium, it probably just skipped their minds because most people are really busy juggling family and friends and life in general, not because they think it's uncool*".

3.4.3. Motivators

The most commonly reported motivator was found to be taste, "*I tend to click for the recipe based on whether it looks delicious and if the ingredients seem healthy*". A few participants highlighted the

importance of cost as a motivator. One participant explained that money saving tips could act as a motivator, "*as a uni student, I find that anything to do with money saving really gets my attention*". It was indicated that the behaviour change should seem attainable, as illustrated by, "*I think above all, getting the proper calcium intake needs to seem easy to achieve. I already know that I don't eat well but changing my habits requires changing my mindset*".

Two participants suggested using 'freebies' and providing more examples of calcium-rich foods to get the attention of young adults, "*I think you guys should give more examples about easy get food with abundant calcium, especially, with good taste will be better, or provide some menu, or freebie on the street to us*". Further suggestions for motivation included having more social media posts on the risks of inadequate calcium intake, as demonstrated by, "*increasing understanding of how having an adequate intake of calcium can affect more than just bone healthy; increasing understanding of all the benefits of calcium and more information on calcium sources*". It was indicated that the negative effects of low consumption should be communicated clearly, as shown by "*makes posts that explain the detrimental health effects of not taking in calcium and at the end provide an easy nutritional recipe that can help boost it*".

4. Discussion

To our knowledge, this is the first study to examine aspects of messaging for improving calcium intake in young adults. All text messages and messages with posts scored similarly. Relevance to the age group is obviously needed and recipes and tips keenly sort. While young adults like the idea of social media posts, they are not keen to engage in sharing posts with other members in a research setting and would be unlikely to share the Facebook intervention posts with a friend.

A previous study measuring public engagement of the National Cancer Institute Facebook page reported that posts with photos received significantly more likes, comments and shares [26]. Visual content on social media can grab the attention of readers and portray information more efficiently than plain text messages [27]. For example, photos on Facebook will typically generate 53% more likes compared to a post containing text only [28]. A few respondents commented on picture quality as the most important factor, which is comparable to an online survey conducted worldwide where production quality was rated as the number one factor [29]. Moreover, the preference for meal inspiration posts and recipe demonstrations indicate the great potential of video technology in educating young adults. Mayer's cognitive theory of digital learning explains that viewers can only process a limited amount of information at one time as visual and auditory information are processed via different pathways [30]. However, as video technology comes with pause and rewind options, it allows the learners to process more information [31]. A previous study investigating vegetable intake in Australian young adults reports similar findings, where food pictures and recipe ideas were ranked as highly preferred while awareness raising posts received a lower ranking [32].

To make the messaging relevant to young adults, we need to understand that they lead busy lifestyles and want suggestions for eating more calcium-rich foods to provide quick and easy options without the need to invest large amounts of time and energy into cooking [33]. The messages must also contain something of relevance for the present time in their lives rather than the threat of something in the distant future [34]. The scoring of the text messages did not differ by the tone; however, direct comparisons are not possible because of confounding by content and length. Previous research has found a preference for GenY or authoritative tone [21,32]. Our qualitative research here did indicate that the language of young adults was preferred. Gender-specific messaging may be particularly helpful [35,36]; as research suggests that young males are motivated by messages relating to physique [32,37,38]. In contrast, young females are motivated by messages that improve their self-confidence [39,40]. There was acceptance of messaging about health consequences, raising awareness and increasing knowledge, and explaining why it is important to take action, which is consistent with literature [41].

Regarding the types of messages that motivate participants to engage and change behaviour, the appeal, taste and cost of suggested foods and recipes is important. Our comments from

participants showed that taste was an important factor influencing food choice which is similar to other studies conducted with young adults [42,43]. Some participants indicated that cost influenced their food choices, which is also consistent with earlier qualitative work with young people [21,43–46]. The majority of respondents were reluctant to share personal content with strangers, as has been reported previously in an Australian study involving healthy young adults [32]. Similarly, studies conducted with young adults with diabetes or common mental health disorders reveal that many choose not to disclose health experiences to avoid potential negative implications for identity construction [47]. In particular, Facebook has been identified as a space for constructing personal and group identity [48–51] which means that posting or "liking" content can mirror offline social interactions and be seen as performing to identity [52]. The users are concerned about how audiences might view their disclosure and even the seemingly innocuous act of "liking" pages can affect their management of identity [47].

5. Study Limitations and Future Implications

The strengths of this study include the large sample size which has allowed for the generation of quantitative and qualitative data. While most of our respondents included 18 to 25-year-olds enrolled in tertiary education, some were also employed in the workforce. A limitation of the study was the underrepresentation of young males, as they were far from reaching equal proportions. However, this is similar to other Australian research that has found it more difficult to recruit men into population studies [53]. To reduce the burden on the respondents, only one set of messages and one set of Facebook posts were tested. No conclusions about the preferred tone of messages can be made because of confounding by length of messages as the qualitative research revealed length matters and variations in content is another confounder; using only one set of messages limits the generalizability of the scoring; the posts made with the images are not directly comparable because different foods were depicted each time and this confounds rankings. The qualitative comments provided insights on the preferred tone and type of messages and showed that images are well received. The findings of this research were part of formative evaluation for an intervention aimed to improve calcium intake in Australian young adults. Therefore, caution should be exercised when interpreting these findings for other groups, especially those from other countries or with different cultures.

6. Conclusions

Personal relevance of messages and targeting motivations, as well as tone, length and aesthetics must be considered in developing social media based interventions. The findings captured in this survey together with findings of previous research will be used to refine the design of a Facebook intervention to improve calcium intake in young adults.

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Chapter Seven

Design of the CAlcium Nutrition- Dietary Opportunities (CAN-DO) intervention to promote dietary calcium intakes

7.1 Introduction to the chapter

In Chapter Five and Six, the formative research with young adults to understand the needs and wants of the target population was conducted. In order to develop an effective intervention, it is important to implement a theory-based and systematic approach. The COM-B system of the Behaviour Change Wheel was used to guide analysis of the focus groups. This chapter applies the learnings from Chapter Five and Six to develop the CAN-DO social media intervention to improve calcium intake using the Behaviour Change Wheel framework. This chapter outlines the theoretical framework for a three-arm randomised controlled trial that will be described in the next chapter.

7.2 Introduction

The systematic literature review in Chapter Four revealed a limited number of interventions to improve the poor calcium intakes in young adults. Many of the interventions were paper-based and/or lacked a theoretical construct. Since young adults are heavy users of smartphones, internet, and social media (1), interventions using these platforms have the potential to play a pivotal role for public health intervention delivery and should be made a research priority (2). In recent years a number of electronic interventions to address low calcium intakes of young adults have been developed. These have included two with a theoretical basis: an online course system using Social Cognitive Theory; (3) and electronic mail using Health Belief Model; (4)

and two lacking an apparent theory using an app for self-monitoring of calcium intake (5) and another text messages (6).

While there are many theories of behaviour change with similar concepts (7), there is little guidance on how to choose an appropriate theory for a given population and setting (8, 9). Most frameworks provide limited "how to" support on the implementation process (10). This could be why theory is often not included in the design of nutrition interventions. Recent finding from a systematic review suggested that there is limited information on how intervention design can support behaviour change as most interventions lack transparency on describing the "active components" or distinct Behaviour Change Techniques (BCTs) (11).

The learnings from the focus groups in Chapter Five were used to build an intervention based on the theory behind the Behaviour Change Wheel. Michie et al. proposes that an individual requires psychological and physical capability (C), physical and social opportunity (O) and automatic and reflective motivation (M) to perform a specified behaviour (B) (12, 13). The stepwise approach to building an intervention to improve calcium intake that addresses these theoretical components is described in this chapter. Young adults had indicated that Facebook was a suitable the delivery platform based on formative research (14, 15) and thus is used as the main communication channel. In addition, previous electronic interventions with young adults had indicated that the addition of text messages improved the results (16-19). Thus, the intended intervention was developed to have two Facebook arms one with Facebook only and one with Facebook boosted with text messages. It is known that young adults do "lurk" in social media where they passively review content without posting or visibly connecting to others (20-21). This chapter shows the 8 steps of development of both versions of CAN-DO program using the COM-B framework. It focuses on the theoretical aspects and the methodology for the CAN-DO program that will be tested in a randomised controlled trial detailed in Chapter Eight.

7.3 Methods

A theory-informed approach based on the Behaviour Change Wheel (BCW) with eight separate steps was followed to construct the program. The problem was defined in behavioural terms; the target behaviour specified; the findings from the focus groups used to define the changes needed and intervention functions selected from the nine available that would address the deficits in knowledge and skills, opportunity needed and build motivation. Finally, behaviour change techniques from the taxonomy of 93 techniques were selected as the "active ingredients".

7.4 Results

Step 1: Define the problem in behavioural terms

Through our previous empirical work (22, 23) and the existing literature (24), it was identified that young adults, especially women were eating too few calcium-rich foods on a daily basis and thereby not meeting the recommended daily intakes.

Step 2 and 3: Select and specify the target behaviour

The results from the most recent NNPAS indicated most young adults needed to be eating an additional serve of milk or alternatives daily to provide about 250 mg calcium (23). However, it became apparent that this may not be a realistic change to achieve in a short-term intervention based on recent studies that have been successful with this population (3, 6). Therefore, the target behaviour for the current intervention was to improve intakes by about half a serve of milk and alternatives which would be 125 mg of calcium and this could be increased in a graded fashion over a longer period if the intervention is successful. Table 7.1 summarises steps 1 through 3. As shown in Chapter Three, breakfast was a meal with relatively high calcium

intakes so apart from breakfast recipes were developed for lunch and dinner to increase intakes (see Appendix 7.4).

Table 7.1 Specification of target behaviour

What is the target behaviour?	**Improve calcium intake of young adults in a six-week intervention**
Who needs to perform the behaviour?	Young adults aged 18-25 years
What do they need to do differently?	Need to consume calcium-rich products throughout the day
When do they need to it?	During snack and main meal times
Where do they need to it?	Could be a range of settings including home, work, tertiary institutions (university or TAFE), public transport (bus or trains),
How often do they need to it?	Everyday
Who else may be involved in performing the behaviour?	Parents, housemates, friends, partners

Step 4: Identify what needs to change [Analysis and intervention development]

The findings from the focus groups reported in Chapter Five regarding the capabilities, opportunities and motivations of the target population were used to populate an intervention map and identify intervention functions and appropriate behaviour change techniques (see Table 7.2). In brief, capability was identified as having the physical skill to access dairy foods (physical) and awareness on the importance of calcium in the diet, as well as how much was required (psychological). Opportunity was reported as the availability in their environment and financial affordability (physical); and influences from their surroundings (social). Finally, motivation was seen as having an engrained habit due to cultural or parental influences (automatic); and following current social norms and beliefs and personal preferences.

Table 7.2 Intervention mapping showing the assignment of intervention functions and Behaviour Change Techniques within the COM B model.

COM-B model component	Finding from focus groups (step 4)	What needs to happen for the target behaviour to occur?	Intervention functions (step 5)	Description of intervention strategies (examples of application within the intervention)	Behaviour change technique hierarchical cluster/s (step 7)
Physical capability	Most have the physical ability to consume dairy foods and a special case is lactose intolerance	Need to be made aware of other alternate sources of calcium	Enablement	Facebook posts will mention alternate sources for those that may be lactose intolerant.	Shaping knowledge *BCT 5.1 Information about health consequences*
Psychological capability	Lack of knowledge on the importance of calcium in our diet, the different (non-dairy) sources of calcium the number of servings recommended, what constituted a serving and how to incorporate calcium-rich foods other than dairy	Need to provide young adults with information on serve size amounts and recommendations, health benefits of calcium and non-dairy sources of calcium	Education	Facebook posts will be created to -educate on the health benefits of calcium and dairy -educate on recommended calcium intake and serve sizes according to Australian Dietary Guidelines to assist with goal setting -educate on different sources of calcium (dairy vs. non-dairy)	Shaping knowledge, goals and planning *BCT 5.1 Information about health consequences BCT 1.1 Goal setting (behaviour)*
	Some participants did not realise their intake was low	Need to raise awareness about current intake and encourage continued improvement	Education	Facebook posts will educate participants on current intake and encourage participants to set goals	Feedback and monitoring *BCT 2.3 Self-monitoring of behaviour*
Physical opportunity	Availability in their environment Household level: access to calcium products. The convenience of packaged products was favoured (i.e. a tub of yoghurt as a great 'grab on the go' snack) Geographical level: availability of calcium-rich foods in the food supply	Need to provide young adults with information on quick and easy snacks that are suitable 'on the go'	Enablement, environmental restructuring	Facebook post will provide tips on how to pick healthier calcium-rich 'on the go' snacks while ensuring food safety at consumption. Participants will be prompted to substitute to a healthier or more nutritious options	Antecedents, repetition and substitution *BCT 12.1 restructuring the physical environment BCT 8.2 Behaviour substitution*

Social opportunity	Social media was seen as an acceptable platform for the purpose of this intervention. Participants indicated that having models (i.e. public figures or social media influencers) for the behaviour would encourage intake	Influence from peers was not raised but could be made as harnessed over social media.	Enablement	Facebook posts will encourage young adults to like, share and comment which may result in tagging their social circle. While it is not possible to involve social media influencers for this intervention, the Facebook posts will share posts of other participants to mimic role-modelling.	Social support *BCT 3.1 social support (unspecified)*
Automatic motivation	There were cultural influences in their choice of foods (i.e. some drank milk because it was taught to them young). Some participants reported motivation to include dairy as the habit had become engrained during their childhood under parental influence	Need to be providing content that are culturally appropriate and accommodate for any special needs (i.e. Asians may prefer lactose free). Need to educated on the importance of calcium and encourage them to reinforce their habits and convey messages to others	Persuasion and training	Facebook photos and videos will include recipes that are culturally appropriate (i.e. tofu and green leafy vegetables for non-dairy or vegan consumers). Facebook posts will encourage young adults to convey benefits to other people around them (i.e. younger siblings) so it becomes an engrained habit.	Repetition and substitution *BCT 8.3 Habit formation* *BCT4.1 Instruction on how to perform a behaviour*
Reflective motivation	Some participants stated that having a greater awareness of the health consequences may result in putting an effort to meet the recommended servings	Need to be educated on the benefits of calcium for chronic disease prevention.	Education, Persuasion	Facebook posts will send weekly messaging informing about the benefits of calcium (i.e. bone health, chronic disease prevention, as an essential nutrient)	Shaping knowledge, comparison of outcomes *BCT 5.1 Information about health consequences* *BCT 9.1 Credible source*

Step 5 and 6: Identify intervention functions and policy categories

The next step was to select appropriate intervention functions for the CAN-DO study. Five of the nine intervention functions were selected (see Table 8.1). The three intervention functions that were most relevant for this intervention were education (increasing knowledge or understanding to increase capability and motivation), enablement (reducing barriers to increase capability) and training (imparting skills to increase opportunity). Restriction, modelling, coercion and incentivisation were omitted as it was considered to be not practical or applicable in this context.

Step 7 and 8: Behaviour change techniques and their mode of delivery

All potentially relevant BCTs were identified and were translated into the CAN-DO study to support behaviour change (see Table 7.2). A total of nine BCTs were selected as appropriate for this intervention and the translated behaviour change actions are described below. Chapter Six described the testing for the preferred messaging and posts in an intervention and these were applied during the preparation of intervention materials.

BCT 1.1 Goal setting (behaviour)

For the two intervention groups, participants were asked to set goals to increase their calcium intake after joining the program and assess their current intake. An infographic was placed as the Facebook cover photo to assist participants in setting their first goal. The infographic educated participants on what a serve looks like and how much young adults require every day. Additionally, participants were asked to set a new goal once they had achieved their goal. This action was performed via Facebook and additional text messages for the Facebook plus text group. This action was performed via text message where participants were reminded to set a new goal after two weeks. The control group did not receive any information on goal-setting.

BCT 2.3 Self-monitoring of behaviour

A free available self-monitoring app was recommended to participants to track their calcium intake. Participants were asked to reflect on their current intake and set their goals using their Android or iPhone app (Loop Habit Tracker and Productive, respectively). They were sent reminders and encouraged to track their intake as part of a behaviour change strategy. The control group was not provided with any information on self-monitoring.

BCT 3.1 Social support (non-specific)

As the future intervention was designed as a three-arm RCT, the two intervention groups (group A and B) could seek support on social media. Participants provided with social support were encouraged to post content, express their thoughts, experiences and share pictures on Facebook if they recreated any of the recipes. The control group was not provided with any social support.

BCT 4.1 Instruction on how to perform a behaviour

The two intervention groups were provided instructions on how to include extra calcium-rich foods in their meals through cooking videos. Participants were provided with an observable example of behaviour through specially designed cooking videos. A range of calcium-rich recipes including breakfast, main meals and snacks were designed for the participants that included detailed instructions with a voiceover. All recipes were budget-friendly, nutritionally balanced and relatively simple for participants to prepare. The videos were viewed for acceptability in focus groups with young adults. A detailed description of content development, recruitment methods, data collection and feedback can be found in Appendix 7. The control group did not receive any form of demonstration. They were provided with a list of calcium containing foods and ways to incorporate them in their diet.

BCT 5.1 Information about health consequences

For the two intervention groups, a pinned post was used to inform participants when they joined the Facebook groups. The pinned post provided a short paragraph on the importance of calcium for development of peak bone mass and links to chronic diseases. Information was also delivered in a written form throughout the intervention which included benefits of calcium intake and recommendations for intake. This was delivered in a verbal (cooking videos) and written form (Facebook post and text messages). The control group received an educational e-leaflet which explained the health consequences at the start of the intervention.

BCT 8.2 Behaviour substitution

Participants in the two intervention groups were provided with continuous prompts to increase their calcium intake (wanted behaviour). This was executed via written Facebook posts and cooking videos. The aim was to substitute unwanted behaviour with a healthier behaviour. Some examples included cooking a calcium-rich recipe rather than eating out, swapping chips with a more nutritious snack with some wholegrain crackers and cheese or using yoghurt-based dips like tzatziki as an alternative to mayo or sour cream. The control group did not receive any ongoing prompts.

BCT 8.3 Habit formation

For the two intervention groups, participants were prompted to perform the behaviour multiple times in order to associate performance with the context (i.e. cooking calcium-rich recipes at home). Participants were shown different cooking videos and encouraged to try the recipes at home with the aim of increasing habit and skills. The control group was not provided with any prompts to assist with formation of habits.

BCT 9.1 Credible source

For the two intervention groups, a pinned post was used to provide participants with links to credible sources. Participants were presented with facts based on credible sources and evidence-based research. In addition, links to additional resources were provided alongside Facebook posts. For the control group, an educational e-leaflet was developed which included a reference list from credible sources.

BCT 12.1 Restructuring the physical environment

Participants were provided with tips to modify their physical environment (i.e. creating a shopping list) and having pre-cooked calcium-rich meals/ snacks to have on the go. The aim was to reduce existing barriers and facilitate performance of the desired behaviour. The control group did not receive any information on restructuring their environment.

7.5 Discussion

This chapter describes the mapping and intervention development process of the CAN-DO intervention based on the Behaviour Change Wheel. The COM-B model was used to map the important barriers and facilitators to improving calcium intake for young adults and formed the theoretical basis for the intervention. The taxonomy of behaviour change (BCTv1) was used to select the relevant strategies. Elements of participatory approach (25) were used as young adults were recruited to conduct the formative research.

To date, researchers have previously used the COM-B model to develop behavioural interventions in a range of healthcare settings which have focused on independent living of older adults (26), physical activity in cancer patients (27), sedentary habits in the workplace (28), smoking cessation (29), gestation diabetes (30), chest injury management (31), medication adherence (32), auditory rehabilitation (33) and promoting gas stove in rural areas

(34). To our knowledge, the current study is the first to apply the Behaviour Change Wheel in this context. The findings reported in Chapter Five suggests that capability, opportunity and motivation play an important role in calcium intake of young adults in Australia. A total of nine BCTs were chosen for the CAN-DO study which were related to providing information, instruction or forming habits. This is in line with a recent review that reports using between four and 10 BCTs for improving cooking and food skills (11).

Data from focus groups in Chapter Five revealed that motivation to change behaviour was low because young adults perceive it as a 'future me' problem and report having other priorities in their diet. The qualitative results from the focus groups revealed that participants had little awareness of the risks of inadequate calcium intake, recommended amounts, serving size and non-dairy sources (14). While it is known that information alone is not sufficient to change behaviour (35), many interventions commonly incorporate nutrition education in interventions (11). Providing information on the consequence of behaviour was the most common BCT; however, it is recognised that a more holistic approach may be required to change behaviour and developing skills in preparing healthier meals (11). Goal-setting and self-monitoring were incorporated to support behaviour change as literature suggests that young adults expressed lack of self-discipline (36). Moreover, an earlier study conducted on young adults indicated that both self-monitoring and goal-setting increased self-efficacy to perform the wanted behaviour (37).

Cooking videos were chosen as the primary visual element for demonstration of behaviour. This was thought to be necessary as statistics from a recent US study indicated that the majority of participants aged 19-24 years had limited to no cooking abilities if they were living at home (38). A recent cross-sectional survey conducted in Australia with adults has found that older respondents and females had a higher level of cooking skills and food skills confidence compared to younger and male participants (39). A high correlation was reported for cooking

and food skills confidence and individuals with higher diet quality scores had greater cooking skills, food skills confidence and consumed less takeaway food (39). A recent review has reported cooking skill interventions to be modestly effective, particularly in improving confidence and food literacy (40). It is crucial to understand the mechanisms of behaviour change to support young adults improve their cooking and food skills (11). A recent review conducted by Hollywood et al. identified the most commonly used BCTs used in cooking interventions which included providing information on consequence of behaviour, providing instructions on how to perform the behaviour and prompting practice (11). It must be noted that these three BCTs appeared across all interventions that were successful in the long-term (11). Moreover, this review reveals the importance of empowering individuals to become involved in practical hands on cooking sessions as studies have shown that incorporating a practical skills component was associated with long-term behavioural change (11). While our intervention does not involve a face-to-face cooking session, it is hoped that instructional cooking videos and recipes will provide young adults with the practical skills to perform the wanted behaviour. The technique of demonstration of behaviour was achieved by encouraging participants to replicate the meal in their own environment. This approach has been found to increase personal relevance of the message in other studies (41, 42).

Since cost and food wastage were raised as an issue, participants were provided with practical tips to restructure their physical environment. This is similar to the "Food Cent$" intervention which involved creating a shopping list and improving access to inexpensive ingredients (43). The social environment also plays a significant role in influencing young adults. Research shows that those who have a weaker in-person social support may experience greater benefits by obtaining support on social media (44). Social media has been labelled as a valuable space for sharing information and for the generation of supportive networks for young adults (45). A recent review by Klassen et al. has reported young adults identifying social media as a useful

medium for information delivery and learning (21). Nonetheless, young adults are often reluctant to share health-related information with strangers as it can affect their social media identity (46, 47). Further research is needed to understand how young adults can be best supported in this context.

7.5.1 Strengths and limitations

The intervention program was underpinned by a strong theoretical base and follows a systematic approach. Using the COM-B framework has enabled input from the target population and identified appropriate behaviour change components to support behaviour change. This chapter illustrates how primary (focus groups, questionnaires) and secondary data (systematic review, secondary analyses) can be applied using the Behaviour Change Wheel to guide intervention development and refinement. It is hoped that future researchers aiming to improve nutrition behaviours will benefit from the steps that has been outlined in this chapter.

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7.7 Conclusion to chapter

This chapter details a worked example of how COM-B model can be applied in the context of developing a nutrition intervention for young adults. This process may be useful to other researchers developing a nutrition intervention or incorporating social media. The next chapter includes further details on development of the randomised controlled trial, recruitment and the findings.

Appendix 7

Appendix 7.1 Ethical approval for conducting focus groups with young adults

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
Human Research Ethics Committee

Monday, 11 September 2017

Prof Margaret Allman-Farinelli
School of Life and Environmental Sciences (SOLES); Faculty of Science
Email: margaret.allman-farinelli@sydney.edu.au

Dear Margaret

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that your project has been approved.

Approval is granted for a period of four years from **11 September 2017** to **11 September 2021**

Project title: **Gathering feedback from short cooking videos to test the acceptability of a social media intervention: a qualitative study using focus groups**

Project no.: **2017/718**

First Annual Report due: **11 September 2018**

Authorised Personnel: **Allman-Farinelli Margaret; Bramston Vienna; Rouf Anika;**

Documents Approved:

Date Uploaded	Version number	Document Name
21/08/2017	Version 1	Face-to-face recruitment script
21/08/2017	Version 1	Focus group questions (verbal)
21/08/2017	Version 1	Online poster
21/08/2017	Version 2	Participant Consent Form
21/08/2017	Version 3	Participant Information Sheet
21/08/2017	Version 1	Pre and post questions
21/08/2017	Version 1	Recruitment poster- tab-flyer

Special Condition/s of Approval

- It will be a condition of approval that you revise your Participant Information Statement and Participant Consent Form carefully for formatting/numbering errors, font/colour inconsistencies and typographical errors.
- As specified in the Research Data Management Policy 2014, it is mandatory that University staff and research students prepare and implement a Research Data Management Plan (RDMP) for all research projects using the University's RDMP tool. To ensure data is stored securely and protected against loss or damage during and after completion of your project, the data storage arrangements detailed in your RDMP must be in line with the Research Data Management Guidelines. It will be a condition of approval that you adhere to this requirement.

Research Integrity & Ethics Administration
Level 2, Margaret Telfer Building (K07)
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ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

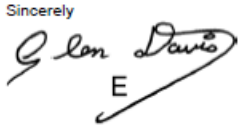
Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

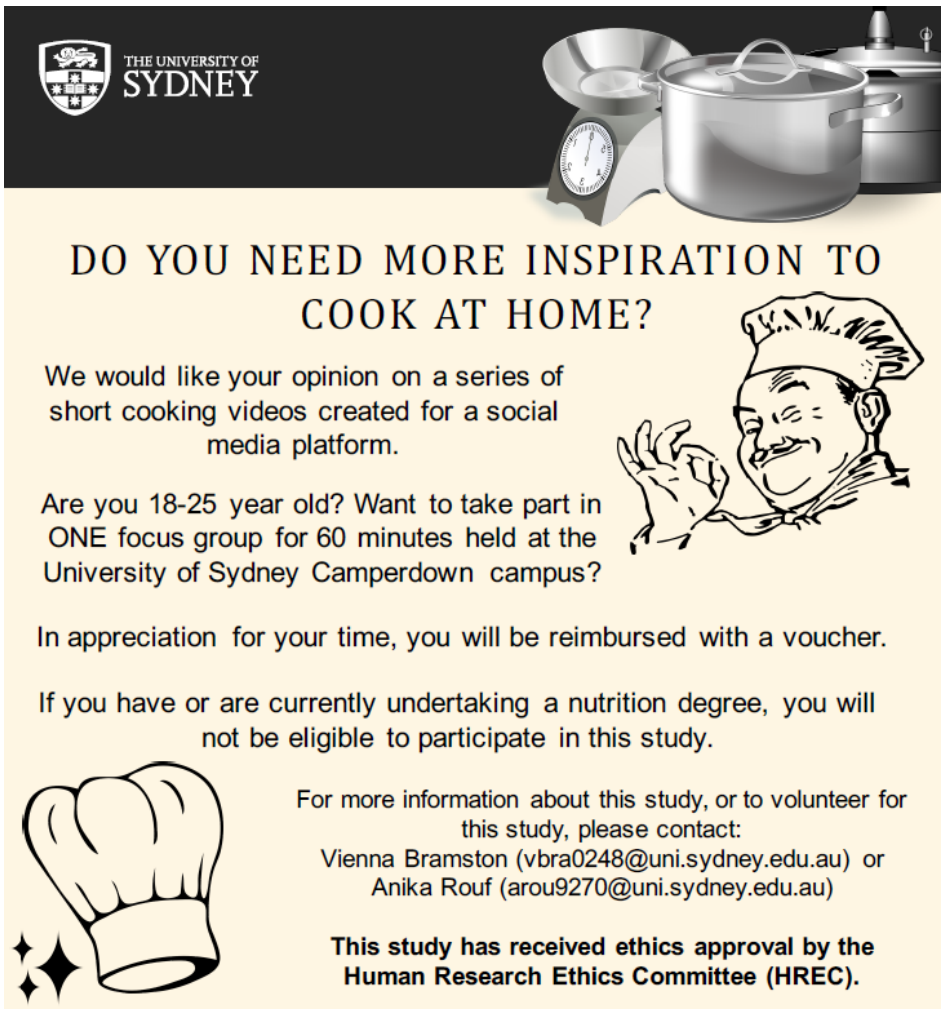
Sincerely



Professor Glen Davis
Chair
Human Research Ethics Committee (HREC 2)

The University of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007) and the NHMRC's Australian Code for the Responsible Conduct of Research (2007).

Appendix 7.2 Recruitment poster used to recruit young adults



Appendix 7.3 Participation information statement

THE UNIVERSITY OF SYDNEY

Discipline of Nutrition and Dietetics
School of Life and Environmental Sciences
Faculty of Science

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Gathering feedback from short cooking videos to test the acceptability of a social media intervention: a qualitative study using focus groups

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study that will involve participating in a focus group to provide feedback on a series of short cooking videos and determine what enables people to cook from home and what may be barriers to them cooking from home, in particularly focusing on calcium as an ingredient. This study will help to identify how the consumption of calcium containing products can be increased in young adults.

You have been invited to participate in this study because you meet the demographics required for this study. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving your consent to take part in this study you are telling us that you:

- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

The study is being carried out by the following researchers:

- Margaret Allman-Farinelli, Professor of Dietetics
- Anika Rouf, PhD Candidate
- Vienna Bramston, Masters Student

Vienna Bramston is conducting this study as the basis for the degree of Masters of Nutrition and Dietetics at The University of Sydney. This will take place under the supervision of Professor Margaret Allman-Farinelli and Ms Anika Rouf.

(3) What will the study involve for me?

You will be invited to participate in the focus group if you are between 18 to 25 years old and not studying nutrition at a tertiary level. At the focus group, you will be asked to complete a short questionnaire to allow us to obtain some basic demographic information and questions on daily food preparation and home cooking practices. The focus group will run in groups of 6-10 people and will involve discussing certain questions to do with calcium, food preparation, home cooking and watching and giving feedback on short cooking videos. The focus group will run for approximately an hour. Questions asked in the focus group will be open ended and will encourage discussion between all participants. Focus group discussions will be audio recorded to enable researchers to go back and analyse and collate data after the focus groups have finished. After the completion of the focus group, you will be asked to complete another short questionnaire which will focus on your opinion of the short cooking videos and motivation to eat calcium containing foods.

(4) How much of my time will the study take?

If you qualify to participate in the focus group you will be asked whether you are able to participate in a focus group that will run for approximately an hour.

(5) Who can take part in the study?

This study requires participants aged between 18-25 years old. Participants who have had previous nutrition education or who are currently undertaking nutrition education will be excluded as their nutrition knowledge would be more than that of an average young adult.

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at The University of Sydney.

If you take part in a focus group, you are free to stop participating at any stage or to refuse to answer any of the questions. However, it will not be possible to withdraw your individual comments from our records once the group has started, as it is a group discussion. Additionally, if you drop out prior to the end of the focus group, you will not be eligible for the incentive of a voucher.

(7) Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study. Participation in this study should involve no physical or mental discomfort. If, however, you should find any focus group questions to be offensive or invasive, you are free to withdraw from answering the survey questions.

(8) Are there any benefits associated with being in the study?

We cannot guarantee that you will receive any direct benefits from being in the study. You may gain some health information from participating from the focus groups. You will be reimbursed with a Coles and Myer $10 voucher for your time after the completion of the focus groups.

(9) What will happen to information about me that is collected during the study?

All data collected in this study will be stored confidentially. Only members of the research team will have access to identified data. The focus groups will be recorded, to allow transcription of the discussion groups. However, you will not be identified in the recordings – we will give you a number at the start of the focus group and refer to you by number throughout. We will also not name you in any of our reports or publications. In our report, we may use quotes from the focus groups to help illustrate points being made, however, you will not be identifiable from these quotes.

Your information will be stored securely and your identity/information will be kept strictly confidential, except as required by law. Study findings may be published, but you will not be individually identifiable in these publications.

By providing your consent, you are agreeing to us collecting personal information, such as age and gender, about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

(10) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?

When you have read this information, Anika Rouf or Vienna Bramston will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact Anika (arou9270@uni.sydney.edu.au) or Vienna (vbra0248@uni.sydney.edu.au).

(12) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell us that you wish to receive feedback by indicating so on the questionnaire. This feedback will be in the form of a one page summery. You will receive this feedback after the study is finished.

(13) What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney *[INSERT* protocol number once approval is obtained*]*. As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** human.ethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

This information sheet is for you to keep

Appendix 7.4

Publication resulting from the development of cooking videos mentioned in this chapter,

Nutrients 2020, 12 (5), 1236

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Author contribution

I Anika Rouf (the candidate) was the secondary researcher involved in developing the research question. The primary researcher Vienna Bramston developed the cooking videos and together we developed the research questions and conducted the focus groups. Vienna prepared a preliminary manuscript and my supervisor extensively rewrote the draft for the submitted manuscript (MAF). All co-authors have provided input to the content of the final manuscript.

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The Development of Cooking Videos to Encourage Calcium Intake in Young Adults

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Abstract: Young adults are among the lowest consumers of calcium-rich foods. As young adults move out of home and commence university, meal skipping, food budgets and poor cooking skills may contribute to low intakes. This research aimed to develop and evaluate cooking videos to educate young adults about calcium-containing foods and provide demonstrations for culinary skills training. Fifteen short videos were designed that required minimal cooking skills, ingredients of low cost, and covered main meals and snacks. Thirty-four young adults (nine males) participated in four focus groups to assess usability and desirability of content and explore barriers to cooking. Individually completed questionnaires assessed knowledge and motivation gained post-video screening. Qualitative data were analysed with both a deductive and inductive thematic approach, and questionnaires using descriptive statistics. Video content was well accepted, most participants reported knowledge was gained and their motivation to prepare food at home and consume calcium-rich foods increased. Cooking videos appear to be a well-accepted alternative to formal classes to demonstrate calcium-rich meals that can be quickly prepared. In the future, the videos should be tested in a trial of effectiveness as social media presents a dissemination opportunity for these videos among university and college students.

Keywords: calcium; young adults; video cooking skills; motivation to cook; social media

1. Introduction

Young adulthood is a time of growing independence from family including completing tertiary education, starting work and moving out of the parental home. It is also a time for changing food habits with young adults often time poor, choosing more convenience foods and preparing fewer meals at home than older adults [1]. Among the reasons for this may be a lack of food literacy, in this age group, defined as the knowledge and skills for planning meals, and selecting and cooking food [2,3]. A nation-wide survey in the UK reported that young adults (18 to 34-years-old) had less confidence in cooking methods such as stewing, steaming, poaching, and oven baking [4]. A recent Australian survey has reported that those aged 18 to 29-years-old had lower confidence in cooking skills than those aged 46 years and over [5].

Interventions in the form of cooking classes have been actioned with some success in developing healthy eating [6,7]. However, there is a need for a less costly means of providing cooking instruction to a larger community of young adults other than face-to-face classes. Social media is widely accepted among this group and cooking videos are popular on social media channels such as Instagram and YouTube. These channels may present an opportunity for nutrition promotion to reach young adults [8] with healthy cooking videos. The impact of video technology on learning cooking skills has previously been explored by Surgenor and colleagues, who taught participants how to prepare lasagne from

scratch under four conditions [9]. Their experiment included three groups inclusive of a video, and one provided a recipe card only which was found to be least helpful in guiding participants through the cooking process [9]. Focus group exploration of the potential mechanisms whereby the video technology (using visual and audio channels) enabled learning in the cooking process revealed that participants developed a better understanding of the cooking process; benefited from visualisation of how the food should appear at each stage of the cooking process; were assisted to achieve a new cooking skill (the complex bechamel sauce); realised that the experience was enjoyable and developed improved confidence [9].

Mayer's cognitive theory of digital learning cautions that due to the pathways that visual and auditory information is processed, learners can only process a limited amount of information at one time [10]. However, video technology such as on YouTube allows the freedom to pause and rewind to enable the learner to process information at their own pace. In a previous study, we asked for young adults' feedback on cooking videos developed in video with text only mode (with music), and text plus voiceover (with music) and participants overwhelmingly preferred the latter [11]. This seems to suggest the young adults could process the audio of voice with background music, and the visual images with text at the same time.

In planning a nutrition promotion program to improve the sub-optimal calcium intake of young adults, it was decided to explore the incorporation of cooking videos to offer simple recipes and build food preparation skills [12,13]. Previously, young adults have indicated they would like to know more about food sources of calcium other than dairy products and about calcium contents in usual portion sizes of foods [14].

It is being increasingly recognized that co-design of technology-mediated health programs with the target consumers ahead of implementation is required [15]. The Theory of Technology Acceptance posits that the perceived usefulness and ease of use of technology will shape attitudes and subsequent intention to use the technology [16]. Hence, understanding the opinions of the target audience on these factors was critical. Therefore, the aim of this study was to develop and test usability and identified usefulness of a series of cooking videos that could be viewed on social media with the target audience—young adults. The videos were specifically designed to offer simple, quick, inexpensive, healthy recipes that provided a good source of calcium and would appeal to a young adult audience, such as university students. In addition, we assessed the perceived change in knowledge and motivation to cook afforded by the video technology.

2. Methods

2.1. Content Development

A student dietitian researcher designed the recipes to include both main meal and snack calcium-rich recipes and to be consistent with the Australian Dietary Guidelines for sodium, saturated fat, and fibre [17]. The Guidelines recommend that foods containing sodium and table salt should be limited, saturated fat should be limited (<10% total energy), and fibre from wholegrains, and fruit and vegetables, should be encouraged (30 g daily). The recipes were intended to require a relatively low level of cooking skills and targeted for the 18 to 25-years-old age group likely to be in tertiary education. Forecast cost of main recipes was less than $AU5 per serve that would be considered low cost. Most ingredients were readily sourced and generic brand varieties of lower cost, except for a low sodium canned fish product and a calcium fortified product. The recipes needed to have a minimum of 150 mg calcium per serve (i.e., half the calcium in one serve milk) so dairy foods, green leafy vegetables and fish with edible bones were featured. A total of 15 recipe videos were pre-tested and finalised (see Table 1). The recipes were analysed for nutrient content using FoodWorks nutrient analysis computer program (v8 2015, Xyris software, QLD, Spring Hill, Australia) and contained between 218 and 653 mg calcium per serve (See Table 1).

Table 1. The 15 Video Recipes (run time in minutes.seconds) and the Nutritional Analysis Per Serve.

Recipe	Energy (kJ)	CHO[1] (g)	Protein (g)	Total Fat (g)	Sat Fat[2] (g)	Fibre (g)	Calcium (mg)
Breakfast Scramble (1.00)	913	8.62	17.8	12.8	1.5	7.2	416.3
Granola (1.57)	1677	62.8	17.5	22.0	5.6	4.4	349.7
Ricotta Pancakes (1.00)	818	43.3	18.8	2.4	1.0	1.8	425.8
Tzatziki (1.11)	874	23.7	10.2	12.1	3.2	3.7	236.9
Cannelloni, Salmon (1.46)	1332	43.9	26.0	11.8	4.0	8.5	419.8
Cannelloni, Vegetarian (1.46)	1130	43.9	18.7	9.6	3.5	8.5	353.0
Chilli Scramble, Vegan (1.27)	1105	13.6	21.0	14.8	2.1	9.7	445.0
Chilli Scramble Vegetarian (1.27)	1594	35.2	30.7	17.5	3.8	12.3	653.0
Fish Tacos (1.19)	1862	45.6	30.4	24.5	7.4	5.3	485.0
Lamb Steak and Mint Yoghurt (2.01)	1328	32.0	26.5	13.2	3.7	7.8	321.1
Macaroni and Cheese (0.50)	676	32.2	13.3	4.4	2.4	0.7	231.7
Sardine Cakes and Yoghurt Dip (1.25)	1326	40.8	29.0	11.6	3.9	5.2	605.9
Spinach and Ricotta Fettuccine (0.49)	963	53.0	11.3	7.4	2.1	4.2	218.0
Stuffed Capsicum, Salmon (1.12)	1207	33.9	26.1	10.4	3.9	8.5	405.0
Stuffed Capsicum, Vegetarian (1.12)	879	29.4	15.9	7.5	3.2	7.4	316.8

[1] CHO = carbohydrate; [2] Sat Fat = saturated fat.

The short cooking videos were captured on a Sony mirrorless digital single-lens reflex camera (DSLR), using a tripod and a 50 mm wide angle zoom lens set to automatically focus. Background music (copyright free), voiceover recording, additional video editing and addition of onscreen written captions were performed using a computer application (v10.0.9 2015, iMovie for Mac, Apple Corp, Cupertino, CA, USA). Length of videos ranged from 49 s to 2 min dependent on the complexity of the recipe. The voiceover featured a female voice providing additional cost (for optional extras like spices) and time saving tips, cooking instructions, and extra nutritional information. Young adults evaluated the videos using a combination of focus groups and questionnaires.

2.2. Focus Groups and Questionnaires

The focus group sessions were led by a female facilitator with previous experience (AR, Dietitian researcher) and moderator (VB, student Dietitian). Eligible participants were included in consecutive focus groups until data saturation was attained, i.e., no new themes were obvious in the focus group discussions [18]. The facilitator conducted introductions among the group and rules of discussion. Then three or four randomly selected videos were screened during each focus group such that all videos were viewed in at least one group. The facilitator used a question plan developed a priori by the two researchers to guide the focus group discussion (see Table 2). This included questions about the videos themselves and questions exploring influences on the participants' cooking abilities and interest in cooking.

Table 2. Questions Used to Guide the Focus Group Discussion.

Video Feedback Questions
Did you find the voiceover helpful?
Do you prefer the female or male voice? Both?
What did you think of the background music?
How do you find the lighting?
Do you think the videos were too short or long in length of time?
What did you think of the transitions between scenes?
Are there ingredients listed you never thought to buy? Will you now give it a try?
Are there ingredients listed you believe are not appropriate?
Do the dishes look tasty/appealing?
Would you prefer they look gourmet or home-made?
Is there something missing from the videos?
Influences on cooking
Did you take cooking classes in school?
Are you interested in nutrition?
Is meal preparation and cooking talked about in your friend group?
Did your parents encourage you to help with cooking and food prep growing up?

Participants were asked to complete written questionnaires before and after screening of the videos in the focus group. The pre-focus group questionnaire collected demographic details, information about how often participants ate home-made meals and their own cooking and opinions about perceived motivators for cooking. A Likert scale was completed to assess perceptions of cooking as time consuming, ingredients as costly, enjoyment of cooking, cooking skills, nutrition knowledge and more convenient alternatives. The post-focus group questionnaire assessed education (i.e., knowledge acquired from the videos) and motivation to cook, willingness to try the recipe at home and perceived cost of ingredients after the videos were shown. The COM-B model of behaviour change suggests that Capability (education and training for knowledge and skills), Opportunity (e.g., costs) and Motivation are important determinants of Behaviour—in this case cooking the recipes [19].

2.3. Recruitment of Participants

To be eligible for inclusion, participants had to be aged 18 to 25-years-old and able to attend the Australian University for one of the focus group sessions. Young adults who were currently studying or previously studied a nutrition related degree were excluded from this study. Recruitment took place over three weeks in September to October 2017. Flyers were posted across the campus of one University on noticeboards, digital boards and on the Facebook networks of the researchers conducting the study. Word of mouth and face-to-face recruitment on campus was also conducted. Participants were provided with a $AU10 department store voucher as a reimbursement for their time. Materials and methods of the focus group were approved by the Human Research Ethics Committee at the University (approval number 2017/718). All participants gave written consent to participate in the study and have the session audio recorded.

2.4. Data Analysis

The qualitative data collected from the focus groups were audiotaped and then transcribed verbatim. The data were coded using the software QSR International's NVivo 11 (v 11.0.0317 2015, QSR International Pty Ltd., Melbourne, Victoria, Australia) and analysed using a combination of inductive and deductive thematic approach. The moderator (VB) read each document on the software and highlighted recurring words, text and quotes to organize data into nodes in NVivo. Codes were formulated based on questions from the focus groups sessions (deductive), but additional codes emerged (inductive) during analysis [20]. The transcripts were coded by one researcher and then all were checked by a second researcher; both authors were trained in NVivo coding. The questionnaire answers were entered into a standardised spreadsheet for analysis. The focus group data have been synthesised with supporting quotations from the participants tabled and guided by the COREQ checklist [21].

3. Results

3.1. Demographic Characteristics

Four focus group sessions, each lasting for approximately one hour, were conducted each with between nine and 11 participants, but with one outlying focus group of only four participants. The thirty-four participants comprised 25 females and nine males. Seventeen participants reported completion of a tertiary qualification already, 15 had yet to complete one or less, and two had completed year 10 of high school only. Most participants did not follow a special diet (24/34), but three identified themselves as vegetarians, two as pescatarian, two trying to lose weight, one following sugar-free, one on lactose-free, and one following gluten-free diets. One participant had diagnosed lactose intolerance but did not follow a lactose-free diet.

3.2. Pre-Focus Group Questionnaire

Only 15 of the 34 participants ate home-prepared meals on six or seven days of the week. About half prepared their own meals and three males and one female never cooked, leaving the cooking to their partners. Lower cost was a major reason to cook meals, as was health. Cooking was identified as time consuming or very time consuming by more than half of the participants (18/34) with seven scoring the time for cooking in the middle of the Likert scale (neutral) (7/34). The cost of ingredients was viewed as a problem by a minority of participants (10/34). Nutrition knowledge was not a perceived barrier for most participants (23/34). Only six participants stated lack of cooking skills was a large problem for them and a majority reported they enjoyed cooking (20/34). The availability of convenience foods such as take-away and ready prepared meals as an alternative to cooking appeared to positively influence about one third of participants not to cook, one third perceived it as a neutral influence, and for the remaining third, it had no influence on home cooking.

3.3. Focus Group Findings

The two major themes from the focus groups were video feedback with sub-themes of video quality, individual food preferences, and other cooking video offerings, and cooking influences with sub-themes of food waste, parental influence, and influencers after leaving the parental home. Table 3 summarizes illustrative quotes organised by sub-themes from the focus group analysis. The demonstration videos were well received. Participants appreciated the presentation of basic cooking skills such as the chopping of an onion. The female voiceover was met with general approval although the consensus was voiceover should not be for the entire length of the video. Background music was seen to complement the voice. The captions contained sufficient information about ingredients and method and the majority of participants did not require additional costing in the captions. Most suggested further facts about the benefits of calcium and sources of calcium-rich foods be included. Participants said it was appropriate the meals appeared homemade rather than gourmet. The preferred platform for delivery of the videos was Facebook with Instagram only suggested by a minority of participants.

The focus groups highlighted many individual food preferences that influenced individual's opinions on different recipes. Only one ingredient was universally disliked, and this was sardines. Food aversions were stated that led to dislike of the content of a video, but the groups acknowledged substitute ingredients offered were helpful and those who were not vegetarian recognized that these options were appealing. There was some discussion of the recipes already available on social media, but participants talked about struggling to find recipe inspiration. Barriers to using the available recipes on social media were that the preparation was time consuming, uncommon ingredients were too difficult to source, and many of them seemed unhealthy. The majority were interested in nutrition and cooking healthily.

Sub-themes arising as influential to participants cooking were food waste, parental influence, and influencers after leaving the parental home. Issues around food waste developed into this being viewed as a barrier to cooking. The idea of wasting food with only one or two people arose and the problem of frozen left-over meals losing taste also featured.

Table 3. Main Themes and Sub-themes from the Four Focus Groups with 34 Participants.

Theme	Sub-Theme	Representative Quotes
Video feedback	Video quality	"looks more approachable," M 21y "type of music has to complement the voice." F 21y
	Individual food preferences	"mum put a piece of zucchini in my salad as a kid and I didn't eat anything around it." F 22y "I find yoghurt in a savoury form . . . weird." F 24y "I would never buy sardines." F 22y "tofu is disgusting; I wouldn't even try it." F 21 y "even if you're not vegetarian, it still gives you that option" F 22y
	Other video offerings	"if I do have most of the things, I just improvise." F 22y "if I didn't have the ingredients or (they) were too expensive I wouldn't make them." F 22y "often quite unhealthy." F 24y "can't be bothered to make the effort to try something else." F 22y "I've been cooking my whole life and I still struggle to chop herbs properly" F 22y
Cooking Influencers	Food waste and cooking	"I choose/prefer to eat out as I live only with my partner and always end up wasting food if we cook at home." F 21y "I'm between houses . . . so that loses my motivation to cook because I don't want food to go to waste." F 21 y
	Parental influence on cooking	"I watched them cook but I don't know how to" F 22y "mum doesn't cook, our oven might not have ever been used." F 21y "it's not as important to pass on that tradition anymore." F 23y"because we're European and French and Italian is all about cooking." F 22y "(I) hate freezing . . . my mum froze everything growing up." M 23y
	Changes after leaving the parental home	"because I had never cooked meat before, I lived off packets of rice and frozen vegetables" F 23y "I just live on two minute noodles every night." F 18y

A mixed response was received on whether cooking skills had been transferred from parents. A majority said their parents had not passed on cooking skills and this was because some parents themselves rarely cooked or if they did cook, they did not teach the children. They believed handing down cooking skills was less important than it had been for their grandparent's generation. For a minority of participants that had received instruction during childhood, food was central to the values of the family. Cooking classes were only available at school to participants who attended a state school in Australia as participants at private male schools or who were educated overseas said they had no opportunities. After leaving home, the participants stated cooking and food habits changed. Cost of food became an important determinant in food choice, and inexpensive ready-to-eat foods such as rice, noodles and frozen vegetables, were popular to address cost and convenience. Some chose to become vegetarian as meat is expensive or for animal welfare reasons. Some began to eat unfamiliar foods after suggestions by friends, e.g., cheaper foods like canned tuna, but the idea of abandoning some foods because a new partner did not like the food also emerged.

3.4. Post-Focus Group Questionnaire

The individual responses to the post-video questionnaire indicated the videos educated (33/34), i.e., provided new knowledge, and motivated (25/34) the majority of participants to cook. Most participants said they would try cooking the recipes at home (31/34) and did not perceive them as expensive (32/34).

4. Discussion

Video technology as a medium for education is widely researched, yet its potential in teaching cooking skills is underexplored. The participants viewed it as an acceptable channel to deliver nutrition education and teach cooking skills simultaneously. The video content was well accepted by the young

adult focus group participants and they provided positive feedback that could be used for revising the current videos and creating additional ones. Our main objectives in recipe design were for them to be simple, inexpensive and healthy, and our post-focus group questionnaire findings reinforced that cost was not of concern, and within focus groups it was expressed that these recipes differed from general offerings on social media because they were healthy, had common ingredients and were not time consuming.

The primary aim of the video content was seemingly achieved; to educate and motivate young adults to cook healthy meals at home using calcium-rich ingredients. Participants overwhelmingly replied they would cook these video recipes at home. However, they would need to be tested on their ability to prepare the recipes to prove skill acquisition. Capability and motivation are important to change behaviour [19]. A review of 59 cooking and food skills interventions concluded that demonstration of techniques alone was unlikely to result in long term change unless the opportunity for actually cooking the recipes was included [22]. Our revised videos must also be tested to evaluate their effectiveness in changing behaviour, i.e., improved food planning and preparation of meals and improved calcium intake. Confidence in food skills including planning, shopping and budgeting have been reported to be more important in improving diet quality than cooking skills alone [5].

Participants associated a lack of cooking skills and food avoidance with their parents or other family members. A cross-sectional survey of more than 1000 people in Ireland reported that those who acquired food and cooking skills, mostly from their mother, during childhood and adolescence were the most confident in their skills, and also had a better quality diet in adulthood [23]. Prior to the focus group, only six participants reported cooking skills precluded them from cooking meals at home and time emerged as the major barrier. Yet during the focus groups, it transpired that even those who said they had cooked for years lacked basic skills such as chopping onions or herbs, others were unable to cook meat, and even if their parents had cooked, the skills had not been passed on. This lack of skills is consistent with that reported among young adults in the UK who were the least likely to be able to cook red meat, oily fish and pulses [4].

The ability of video technology to impart culinary skills warrants discussion. Mayer cautioned of cognitive overload when both auditory and visual pathways must process information [10]. Our previous study found high approval for multiple inputs of voice with background music combined with video with text overlay [11]. The finding that the current participants preferred the voiceover not to be for the entire length of the video may indicate some burden on processing the written text captions, music and voiceover simultaneously. Using videos uploaded to social media would be expected to have acceptance among this age group. Young adults (18 to 24-years-old) are the highest users of social media with YouTube predominant followed by Facebook and Instagram [24]. Video technology is a familiar medium being used in formal and self-education and video games, with multiple input channels, are now used in youth nutrition education [25]. Thus, the findings of acceptance and knowledge gain from cooking videos in this group is not unexpected. The first published investigation of video technology for cooking skills tested a single video with a traditional recipe card under modelling conditions, i.e., they watched the video before cooking the recipe [9]. However, the other two conditions involved "video prompting", whereby participants watched a step-by-step instruction in a guided sequence in one, and in the other, they used the video as they pleased controlling when they tuned in and out as needed [9]. This last condition reduced cognitive overload while maximising the potential for learning those parts of the process most important to the individual cook [9]. There may be age and educational differences between the participants in this study and the current one, and although not specifically stated, the participants in the former were all cooking for a family (likely older), of low cooking ability, and were also worried about damaging tablet devices in the kitchen, perhaps suggestive of less technology acceptance or familiarity. The recipes we designed were basic, but our group was likely younger and more technologically savvy so perhaps more amenable to video technology on social media and working at their own pace for the maximum benefit.

It seems young adults view videos as an acceptable medium to deliver cooking instruction, but their potential to elicit long term changes in meal preparation skills and result in more home cooked meals and better diet quality must be further investigated before any conclusions can be drawn. One other intervention has been delivered via the internet and was especially aimed at improving fruit and vegetable consumption. The effect of four 15-minute cooking shows providing nutrition education and cooking skills on knowledge, motivators and self-efficacy for fruit and vegetables consumption showed that college participants significantly increased knowledge and cooking motivators immediately after the program compared with a control group [26] as was found in this study. However, four months post-interventions, only knowledge remained significantly better.

Two cooking interventions for young adult college students have been delivered face-to-face. In a randomized controlled trial, four two-hour face-to-face cooking classes with a supermarket tour reported greater levels of cooking enjoyment and self-efficacy compared with the control group who only received a cooking demonstration [27]. More recently, 82 young adults at a Brazilian University participated in a randomized controlled trial of a nutrition and culinary program and were compared to a wait-listed control group [28]. The program consisted of five three-hour cooking classes and one supermarket visit over six weeks. The positive effects post-intervention were improved self-efficacy for cooking and the addition of fruit and vegetables and seasonings in cooking, and these were maintained at six months. However, the frequency of cooking at home did not improve. Thus, confidence in cooking improves but we need interventions that lead to more home prepared meals.

There are several limitations to the current research that must be considered. Most participants were female and recruited from one Australian University campus. This means the results may not be generalized to other populations of young adults. Participants volunteered to take part in the study and may represent a group who already have an interest in cooking. Lastly, the number of focus group participants was the minimum needed for data saturation [18].

5. Conclusions

Cooking videos of recipes to improve calcium intake appear to be an acceptable communication channel for providing cooking skills demonstrations to young adults, and may result in improved knowledge and motivation. Social media platforms could potentially be successful modes for delivery of these videos for public health interventions in 18 to 25-year-olds, rather than costly face-to-face practical cooking lessons. However, the videos require testing in an intervention study to see if cooking skills, behaviours and calcium intake improve.

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Chapter Eight

Improving Calcium Knowledge and Intake in Young Adults Via Social Media and Text Messages: Randomized Controlled Trial

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8.1 Publication details

This chapter is a reformatted version containing identical text of the manuscript entitled 'Improving Calcium Knowledge and Intake in Young Adults Via Social Media and Text Messages: Randomized Controlled Trial' published in *JMIR mHealth uHealth*, 2020, Volume 8, Issue 2. DOI: 10.2196/16499 (*see Appendix 8.15*)

8.2 Author contribution

I Anika Rouf (the candidate), MN and MAF contributed to the conception and design of the study. I conducted the research, analysed the data (with guidance from Dr Leah Shepherd) and drafted the manuscript. MAF contributed to interpretation of the results and editing of the manuscript. All authors have read the final version of the manuscript.

8.3 Introduction to the chapter

Chapter Seven has outlined the theoretical framework for the CAN-DO study. This chapter reports on the effectiveness of the program using a three-arm randomized controlled trial. The

three arms are Facebook intervention, Facebook with text messages and a control group. The primary outcome is a change in calcium intake while the secondary outcomes are a change in knowledge, habit formation, self-efficacy and motivation for consuming calcium-rich foods. Engagement with the program was also assessed.

8.4 Abstract

Background: Calcium is an important nutrient for the attainment of peak bone mass during adolescence and young adulthood. However, these life phases are characterised as hard to reach for health promotion. Social media platforms offer a promising channel as they are relatively low cost but used ubiquitously by youth.

Objective: The aim of the CAN-DO study was to conduct a randomized controlled trial to test the effectiveness of Facebook alone or with text messaging as channels to deliver a theory-based program to encourage optimal calcium intake.

Methods: The intervention was a three-arm parallel trial. Young adults aged 18 to 25 years were recruited through university and social media for a six-week trial. Participants were randomized to one of three arms (Facebook posts; Facebook posts plus text messages; and Control group that received an e-leaflet containing information on calcium intake). The primary outcome was change in intake of milk and other calcium-rich foods and secondary outcomes were knowledge, self-efficacy, motivation and habit formation concerning calcium-rich foods. Changes were assessed before and after the intervention and the differences in change between groups compared using multivariate regression models with multiple imputations for missing data.

Results: A total of 211 participants (30.3% males) participated (mean age 21.4; SD 2.1). At the end of the program no increase in milk intake (OR 1.51 95% CI 0.61-3.75 Facebook; OR

1.77 95% CI 0.74-4.24 Facebook plus text messages; P=0.4076) nor calcium-rich food was detected (P=0.5686). There was a significant improvement in knowledge in the Facebook plus text message group (P= 0.0004) but habit formation improved less than in the other two groups (P= 0.0127). Our results showed a moderate level of engagement with intervention content and positive qualitative feedback from participants.

Conclusions: The CAN-DO study delivered via Facebook (with the additional support of text messages) was found to improve knowledge and was acceptable among young adults. However, further research is needed to better understand social media engagement and how to optimise the program for participants to be sufficiently motivated to increase their intake of calcium-rich foods.

8.5 Introduction

8.5.1 Background

As adolescents and young adults become increasingly independent, it is not uncommon for lifestyle behaviours to be adversely affected [1]. This may include decreased physical activity, increased rates of smoking and alcohol consumption, weight gain and decreases in home prepared meals [2-5]. Previous studies have shown that young adults are difficult to reach with traditional health promotion strategies [6, 7] but it is important to support young adults through this transition to establish healthy dietary patterns for their own future health [3, 8, 9] and to potentially serve as role models to their children [10, 11].

Among the consequences of poor-quality diets is a low intake of calcium which remains a global concern [12] and among Australian young adults [13]. A secondary analysis from the most recent Australian National Nutrition Survey 2011 to 2012 shows that 69% of males and 83% of females aged 19 to 25 years failed to meet the Estimated Average Requirements

(EAR) for young adults [14]. An adequate intake of calcium in adolescence and young adulthood is important for attainment of peak bone mass and prevention of osteoporosis in later life [15, 16].

Our previous formative research has delved into the barriers and enablers to achieving adequate calcium intake for this population and revealed a gap in knowledge with respect to what amount of calcium-rich food constitutes a serve and the daily number of serves recommended [17]. Their level of motivation to improve calcium intake was low because a lack of knowledge meant more calcium seemed unnecessary and financial factors influenced the opportunity to consume calcium-rich foods wherein milk was seen as low cost but sources such as nuts and fish of a high cost [17]. When asked about an appropriate medium to deliver an intervention program, the focus group participants preferred to learn from social media platforms and Facebook was ranked as the preferred platform [17].

Young adults are ubiquitous users of social media [18]. Almost 90% of young adults (18-29 years) access social media platforms at least once per day [19] so it has the potential for wide reach in an intervention. To date, the small evidence base for the effectiveness of nutrition-related interventions using a commercial social media platform, such as Facebook is inconsistent and warrants further investigation [20-22]. Our previous meta-analysis of the effectiveness of interventions to increase calcium intake demonstrated a small effect size [23] but indicates that research into an intervention to improve calcium intakes of Australian young adults is warranted.

8.5.2 Objective

A previous Facebook intervention for weight loss in young adults found that the use of social media combined with text messages was effective for weight loss but not Facebook alone [20]. Previous electronic health interventions conducted in young adults found a high level of

acceptability and engagement with text messages and effective dietary changes [24-26]. Therefore, the aim of this study was to determine the effectiveness of an educational and motivational program to improve calcium intake in young adults and whether the addition of text messages enhanced behaviour change when compared to the Facebook arm alone.

8.6 Methods

8.6.1 Trial design

This was a three-arm parallel trial with a 1:1:1 allocation ratio. The three groups were Facebook intervention (Facebook); Facebook intervention plus text messages (Facebook plus text); and e-leaflet containing information on calcium intake (Control). Sample size was determined using GPower a statistical power analysis software [27]. To detect a mean difference of 125 mg calcium intake with P= 0.05 and 90% power assuming a standard deviation of 259 mg, a sample size of 45 was required per arm and increased to 75 to allow for 40% drop out.

8.6.2 Participants

Young adults (males and females) aged 18-25 years were selected as this is the period where peak bone mass development is reached [28, 29]. Inclusion criteria included owning a smartphone and a Facebook account. Exclusion criteria was having completed a nutrition course or currently undertaking a nutrition course on the basis of their high existing level of nutrition knowledge. Additionally, any participants with a food allergy, known lactose intolerance or currently taking calcium supplements (but not multivitamins) or eating disorders was excluded.

All materials and methods of the intervention were approved by the Human Research Ethics Committee at the University (HREC). The ethics approval number is 2018/597. Each

participant was reimbursed with a $10 voucher after completing the final questionnaire. This offer did not impact the voluntary nature of consent as it was provided after the intervention finished rather than at the time of consent. The reporting of outcomes was guided by the CONSORT-EHEALTH checklist [30]. As neither the primary outcome or the secondary outcomes were clinical measurements the study was not entered into a clinical trials registry.

8.6.3 Randomization and concealment

A randomized sequence generation was used to allocate the participants. The randomization was performed by two independent researchers who were not study investigators.

8.6.4 Recruitment

Recruitment strategies included: social media (posts to friends and paid advertising on Facebook); posting on University website (*volunteer for research study*); flyers (on campus noticeboards); volunteers on a research database (previous volunteers who took part in nutrition research and agreed for contact in the future) and active face-to-face recruitment. For each of the above-listed recruitment methods, the potential participant was made aware that participation was voluntary. Interested participants accessed the screening questionnaire for eligibility before joining the study.

8.6.5 CAlcium Nutrition-Dietary Opportunities Program

A theory-informed step-wise approach was used to develop the CAN-DO (CAlcium Nutrition- Dietary Opportunities) program using the Behaviour Change Wheel system [31]. This framework posits that an individual requires capability (C), opportunity (O) and motivation (M) to perform a certain behaviour (B) and includes a series of nine intervention functions that can be mapped to the COM-B components [31, 32].

The aim was to build relevant knowledge (capability) and influence beliefs and attitudes in order to generate intentions for individuals to change behaviours (reflective motivation). The details of the intervention functions and relevant behaviour change techniques are shown in Table 8.1. In brief, the behaviour change techniques included goal setting (behaviour), self-monitoring of behaviour, social support (unspecified), instruction on how to perform a behaviour, information about health consequences, behaviour substitution, habit formation, credible source and restructuring the physical environment.

The content of the intervention was developed in two parts. A range of instructional videos were created to build skills in cooking calcium-rich, low-cost and mostly plant-based meals. These were tested in focus groups for acceptability and refined based on the feedback [unpublished findings]. The next step was to design text messages and Facebook posts tailored to the preferences of young adults as indicated in prior formative research [33]. The intervention content was focused on educating on calcium containing food sources and recommended serves, tips for including more calcium and recipe videos that provided instructions on how to incorporate calcium in main meals and snacks. Text messages were kept short (less than 160 characters) and designed to complement the Facebook posts. Text messages and Facebook posts also reminded participants about setting goals and tracking progress for habit formation and created social support via posts and two-way text messaging. An infographic was created to inform participants of the recommendations and set as a cover photo on the Facebook page (Figure 8.1). The e-leaflet that was provided to participants in the control group is shown in Appendix 8.1.

Table 8.1 Details of behaviour change techniques (BCT) with an example. BCTs were derived from Behaviour Change Technique Taxonomy (v1)

Intervention function/s	BCT code	Name of BCT	An example of a Facebook post	An example of a text message
Enablement	1.1	Goal setting (behaviour)	Male and females aged between 18 to 30 years should aim to consume about 1000 mg or 2.5 serves of dairy and/or alternatives per day. How much are you having? Check out this infographic which shows examples of what counts as a serve and set yourself a goal to have one more serve per day.	Hi [insert name], it's Anika from the CAN-DO program. It's time to set your goals and start tracking! Have you downloaded your app and set a goal? Please reply to this message by typing YES or NO
Enablement	2.3	Self-monitoring of behaviour	Calcium intake is low in the Australian population. 44% of males and 71% of females aged 18-30 years don't get enough. Monitoring your progress can be useful when trying to establish new habits. You can use the app 'Productive' (for iPhones) and 'Loop Habit Tracker' (for Android) to track your intake.	Hi [insert name], are you still using the app to track your goals? Please reply to this message by typing YES or NO
Enablement	3.1	Social support (unspecified)	Have you tried tofu? It is a great alternative to eggs and can be scrambled together with leftover veggies for breakfast. PS: Do you have any breakfast ideas you'd like us to share? Let us know what recipes you have tried in the comments below :)	Hi [insert name], it's Anika from the CAN-DO program. Did you check out the Facebook post yesterday? Give us a thumbs up if you like it
Training	4.1	Instruction on how to perform a behaviour	Not only is fish great for heart health, but some varieties are a good source of calcium. You can opt for canned options such as salmon or sardines that will save you time and money. Check out this salmon cannelloni recipe for a delicious way to cook with canned fish.	Hi [insert name], Have you tried any of the recipes from the cooking videos we've shared so far? Please reply to this message by typing YES or NO.
Education	5.1	Information about health consequences	It is important to get your calcium everyday as it can lower your risk of chronic diseases. Here's a photo of a	Hi [insert name], Did you know that calcium is important for your bone strength? To

			veggie platter I created recently. I used the Tzatziki recipe shared on Monday as a side dip to boost the flavour. Make sure you give this a go and share your veggie platter with us :)	up the calcium, why not try anchovies and vegetables on your pizza.
Enablement	8.2	Behaviour substitution	Is takeaway your go-to for work lunch? Try cooking larger amounts at dinner and taking the leftovers the next day for a healthier alternative. These delicious stuffed capsicums contain ricotta and parmesan and taste even better the next day. You can even use canned salmon to bump up the calcium content.	Hi [insert name], Do you get afternoon munchies? Why not swap those chips with some wholegrain crackers and cheese? Cheese is a great source of calcium and protein, and will help you beat the 3pm slump.
Training	8.3	Habit formation	Research has shown that eating breakfast improves your cognitive function and memory. If you are not a breakfast eater, it's time to change and look after yourself! Here's an overnight chia pudding recipe for you to try.	Hi [insert name], How much calcium are you having now? Even if you've only increased a little, WELL DONE! You're on your way to healthier habits.
Persuasion	9.1	Credible source	Did you know that low fat dairy products have just as much as calcium as regular varieties? The Australian Dietary Guidelines advise that more than 50% of intake from dairy foods should be reduced-fat varieties. Check out this infographic!	Hi [insert name], Research shows that having calcium at breakfast increases your chance of meeting your requirement. Did you have your breakfast today? Reply YES or NO
Environmental restructuring	12.1	Restructuring the physical environment	Need some meal prep inspiration? Here is a Mac and Cheese recipe you could try at home. Having pre-prepared meals in your fridge will help you avoid the temptation of take-away and keep you on track with healthy eating. TIP: to save time, you can use multiple containers to store so it is ready to grab and go for the next day!	Hi [insert name], Some canned varieties of fish with bones like salmon and sardines are a great source of calcium. Stock your pantry with canned fish for a quick calcium-rich sandwich filler

[a]BCT: behavior change technique.
[b]BCTs were derived from Behavior Change Technique Taxonomy (version 1).
[c]CAN-DO: CAlcium Nutrition-Dietary Opportunities

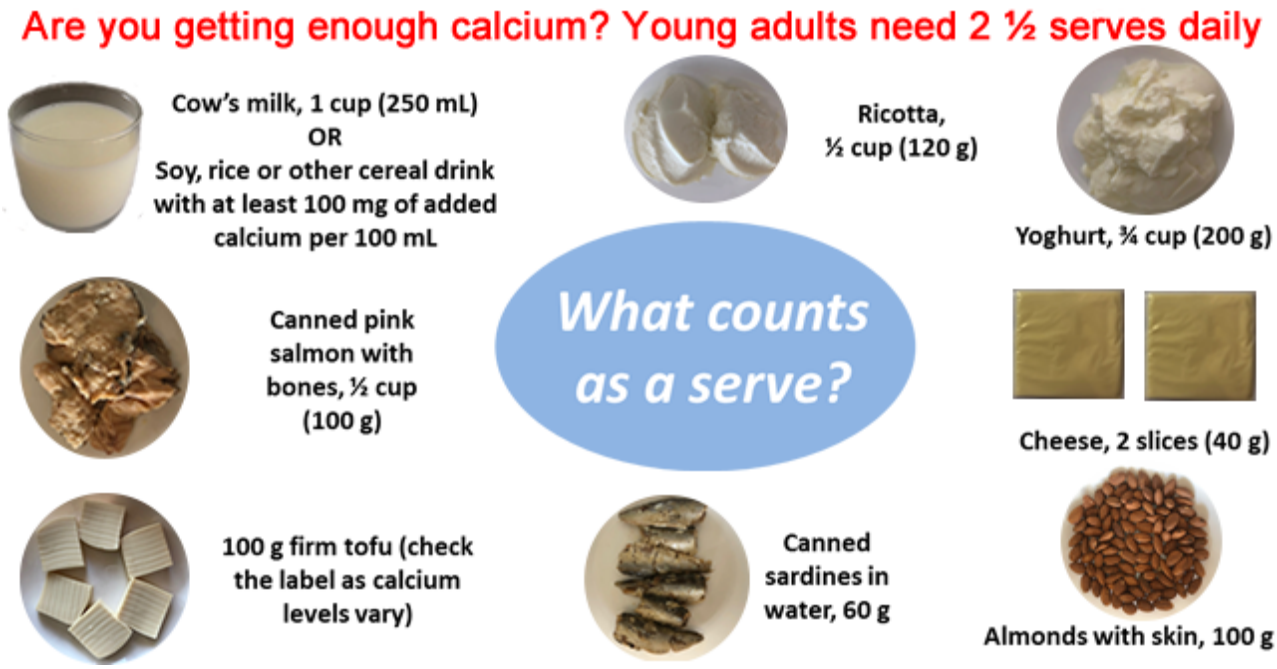

Figure 8.1 Infographic to inform participants of the recommendations

8.6.6 Procedures

Interested participants completed a screening questionnaire hosted on Research Electronic Data Capture (REDCap) [34], where they could find out more about the study by reading the participant information statement and check their eligibility. Participants who were not eligible to participate were provided with the Australian Dietary Guidelines as a resource. Eligible participants completed the consent form and proceeded to the baseline questionnaire. After completing the baseline questionnaire, each participant was randomized to Facebook, Facebook plus text or Control and received an email with their group allocation. Participants in Facebook and Facebook plus text were invited to join a closed Facebook group where a post was made every alternate day by the researcher (AR). The site had a pinned Facebook post used to ensure that all participants were provided with background information which included links to educational resources and an overview of the intervention. Screenshots of the posts are shown in Figure 8.2. The two Facebook groups were kept separate to avoid

potential contamination between groups. Additionally, participants in Facebook plus text were sent text messages every alternate day to the post. Participants in both intervention groups were encouraged to set goals using apps available on iPhone (Productive- Habit Tracker) and Android platforms (Loop- Habit Tracker) and self-monitor their progress. The control group were emailed once with an e-leaflet on calcium and did not receive any continued support on social media. This minimal intervention was to maintain their interest in completing the study.

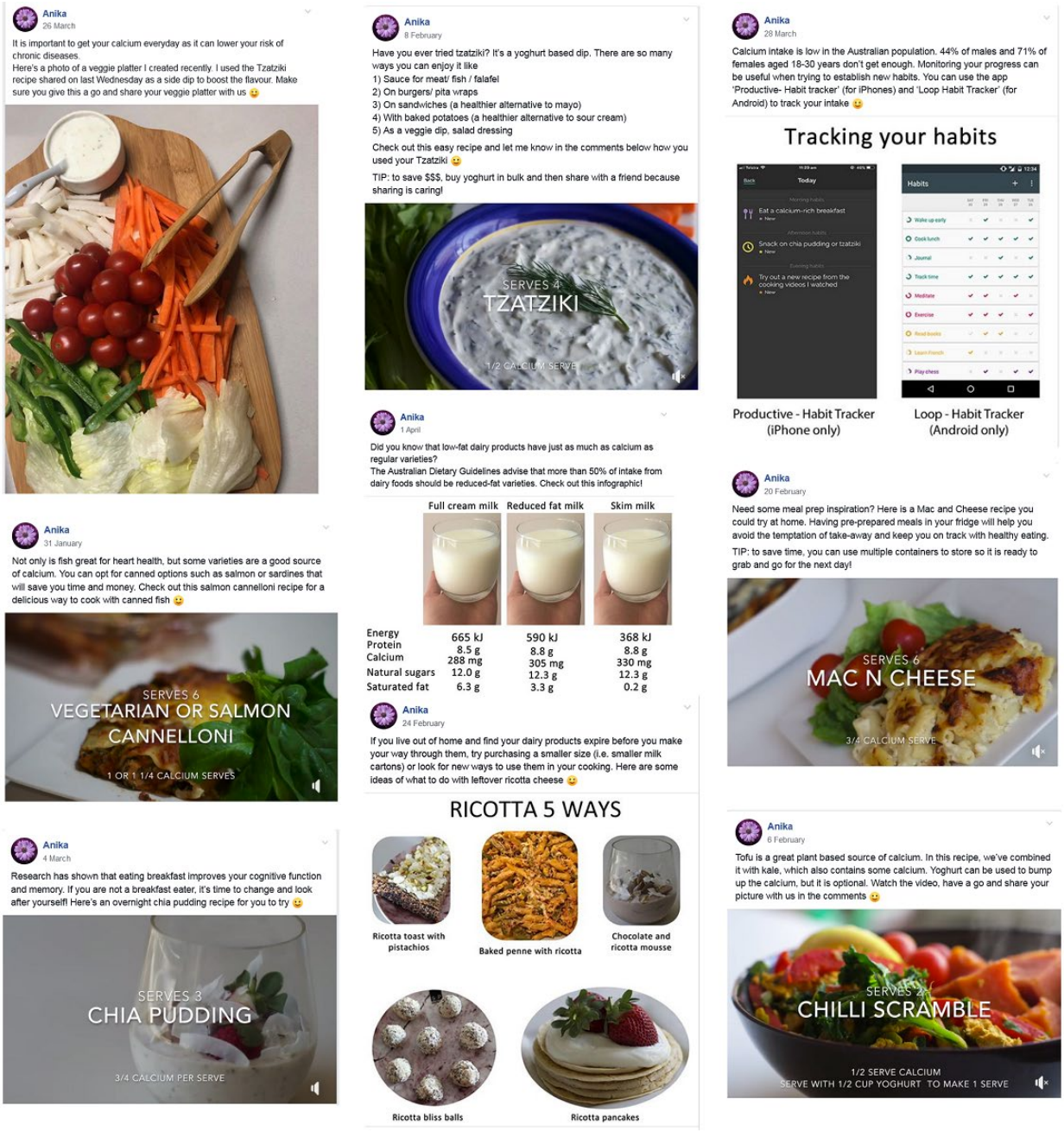

Figure 8.2 Screenshots displaying Facebook posts that included photos, videos and the tracking apps for goal-setting and self-monitoring

8.6.7 Measurement of outcomes

Demographic information was collected from all participants which included age, gender, educational level, postcode (for categorising socio-economic status), occupation and income through a Web-based platform REDCap [34]. The postcode was used to categorise the socio-economic status of participants using Socio-Economic Indexes For Areas (SEIFA) [35]. All outcomes were assessed at two time points which were at baseline prior to commencing the study (T0) and end of intervention (T1) via a Web-based questionnaire on REDCap.

The primary outcome (calcium intake) was estimated using a validated calcium-specific food frequency questionnaire that asks about intake over the past week [36]. Milk was measured in cups ranging from half a cup to more than four cups and the other calcium rich foods (30 foods and beverages included) by weekly frequency of intake only. The secondary outcomes measured the impact of the intervention on determinants of calcium intake which included knowledge of calcium recommendations and serve sizes, self-efficacy, motivation for consuming calcium-rich foods and habit formation. Knowledge was assessed by participant's ability to identify sources of calcium (maximum of 8), a correct serve of calcium (maximum of 8) and stating the calcium requirements for their age group (maximum of 2) using a researcher-designed questionnaire as no validated questionnaire could be found. The questions have been included in Appendix 8.2. A Five-Item Likert Scale questionnaire previously validated for other dietary behaviours was adapted to measure self-efficacy for improving calcium-rich food consumption. The maximum score possible was 25; a higher score indicated stronger self-efficacy [37]. Autonomous and controlled motivation for consumption of calcium was measured using a Four-Point Scale. The questions were adapted from the Self-Regulation Questionnaire [38, 39] where a higher score indicated greater motivation (score out of 16). Habit formation for calcium intake was measured using the

validated Four-Item Seven-Point Scale Self-Report Behavioural Automaticity Index (SRBAI) [40]. A greater score indicated a higher automaticity to perform certain behaviour.

8.6.8 Engagement and process evaluation

Engagement with the platform was measured quantitatively and qualitatively as research indicates the need to do both [41]. Quantitative measures were obtained from recording Facebook analytics. After all participants had completed the intervention, the number of participants who had seen, liked and commented on the Facebook posts was recorded. For the Facebook plus text group, the number of replies to text messages was counted for each participant and the content was analysed using qualitative methods (see Qualitative Analyses below).

Feedback regarding acceptability of the program were collected via open response questions regarding ease of use, usefulness of program, likelihood of recommendation to others and overall enjoyment using Likert scales (5 being highest). The other optional questions were related to intervention experience and uptake of content, as well as frequency and reason for engagement. The last question provided participants with an opportunity for free text comments.

8.6.9 Statistical Analysis

To account for all participants, an intention-to-treat analysis with multiple imputations for missing values was used. This meant that all participants who were randomized at the start of the trial were retained for analyses. Owing to the large amount of missing data, 10 imputed datasets were created based on gender, SEIFA (Socioeconomic Index), cooking frequency per week and baseline intake of primary (milk and calcium intake) and secondary outcomes (knowledge, self-efficacy, motivation and habit) using Stata version 13.1 (StataCorp LP).

The primary outcome of change in milk intake, which was categorical in number of cups, was compared between three groups using a logistic regression model adjusted for gender, SEIFA, cooking frequency, baseline calcium (non-milk) baseline knowledge, baseline self-efficacy, baseline motivation and baseline habit. The quantitative values for change in calcium intake from other dietary sources were compared using linear regression as were the variables for the secondary outcomes of knowledge score, self-efficacy for change score, motivation and habit score adjusted for gender, SEIFA, cooking frequency, baseline calcium intake, baseline knowledge, self-efficacy, motivation and habit. An analysis using completers only was conducted and is available in the Appendix 8.3-8.5. The distribution of missing outcome data at both time points was investigated using counts and percentages across all sociodemographic variables. Furthermore, separate general estimating equation (GEEs) models for binary data were used to investigate any relationships between sociodemographic variables and missingness in each outcome, adjusting for other sociodemographic variables. An independent-sample t test was used to assess differences in number of views, likes, and comments for Facebook posts between the two groups receiving the intervention (SPSS for Windows 22.0 software IBM Corp, released 2013). A P-value of less than 0.05 was considered statistically significant for all tests.

8.6.10 Qualitative analyses

The feedback from the final questionnaire was transcribed and analysed using an inductive approach where common themes were grouped together. The NVivo 12 Plus (2018, version 12.2.0; QSR International Pty Ltd) software was used for thematic analyses.

8.7 Results

8.7.1 Participant characteristics

A total of 270 participants attempted the screener questionnaire. Of 270 participants, 59 were ineligible for the study or failed to continue to baseline questionnaire. A total of 211 young adults were randomized into three groups. The flow of participants through the trial is shown in Figure 8.3. The characteristics and demographics of participants at baseline are presented in Table 8.2. The mean age was 21.4 years (SD 2.1) and sample comprised 30.3% (64/211) males.

The majority of participants (139/211, 65.9%) were enrolled in tertiary education. Nearly one third of the participants (65/211, 30.8%) were in healthcare for their field of work or study. Almost two-thirds (134/ 211, 63.5%) of the participants were earning was less than $500 per week. Nearly half (94/211, 44.5%) the sample reported themselves as being the main purchaser for household groceries. The most commonly reported cooking frequency was less than twice weekly for 37.4% (79/211) of the young adults.

8.7.2 Attrition

Overall, nine participants formally withdrew from the study. All participants were from the same arm (Facebook plus text) and opted out by sending a text – an option not available to other participants who could only opt out passively. The dropout time ranged from day 1 to day 29. Only two participants provided reasons which were lack of interest or time. In total, 148 or 70.1% of participants completed the final questionnaire but not necessarily every question.

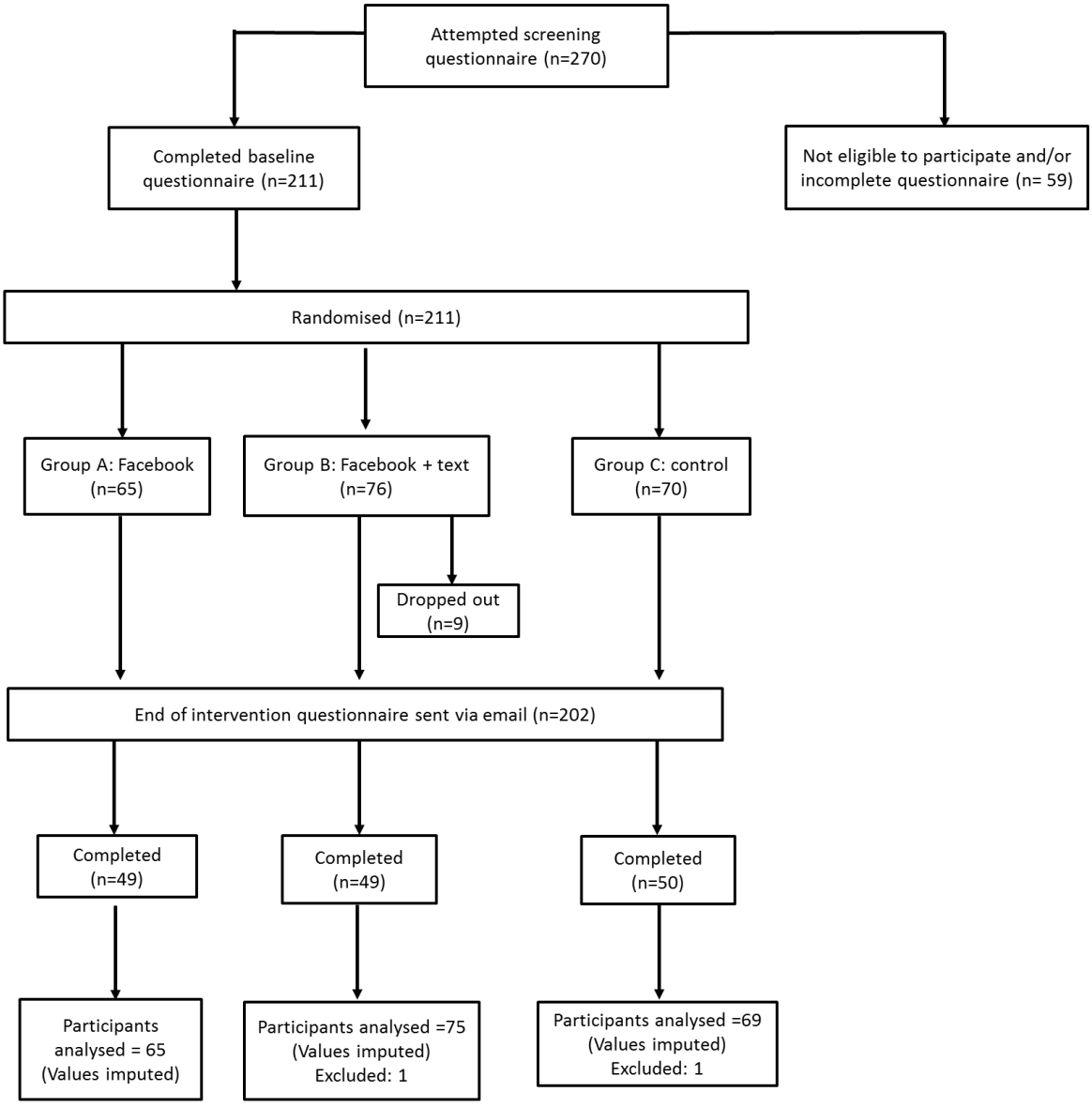

Figure 8.3 Participant flow diagram in the CAN-DO study

Table 8.2 Demographics of participants from the CAN-DO study

Baseline characteristics	**Facebook (n= 65)**	**Facebook plus text (n= 76)**	**Control (n= 70)**
Age in years (mean± SD)	21.3 ± 2.2	21.6 ±2.0	21.4 ± 2.1
Gender (n)			
Male	22	24	18
Female	43	52	52
Occupation (n)			
Student	38	53	48
Full time work	15	14	15
Part-time or casual work	10	5	6
Unemployed	2	4	1
Field of work or study (n)			
Healthcare	22	20	23
Management or finance	5	7	0
Other[a]	38	49	47
Highest level of education (n)			
≤ year 12	35	34	37
Certificate or diploma	14	14	13
Bachelor or postgraduate degree	16	27	20
Prefer not to say	0	1	0
SEIFA (n)			
Quintile 1 and 2	20	25	27
Quintile 3	15	29	19
Quintile 4 and 5	30	21	23
Income per week[b] (n)			
Nil or negative income	8	19	12
$1 - $499 per week ($1- $25,999 per year)	28	32	35
$500- $999 per week ($26,000 - $51,999 per year)	18	15	13
More than $500 per week	11	10	10

Purchaser of main household groceries (n)			
Myself	36	51	7
Others (partner, parents and housemate/s)	29	25	63
Cooking frequency per week (n)			
Less than twice a week	23	29	27
3-4 times per week	24	24	26
5 or more times per week	18	23	17
Rating of own cooking skills [0 to 100] (mean± SD)	63.0 ± 22.4	59.4 ± 21.6	57.6 ± 22.2

[a]Some options from the 'other' field of study or work include education, office support and management, food service industry, information technology, building and design or construction.

[b]Includes wages/ salaries, government benefits, allowances and other income excluding tax, superannuation contributions or any other automatic deductions.

8.7.3 Outcomes

Results from 209 participants (data from two participants could not be imputed due to incorrect postcodes) are reported below. Results using completers only data has been included in Appendix 8.3-8.5. The percentage of data that was missing was approximately 35% for milk intake, knowledge, self-efficacy, motivation, and habit respectively, but 75% for calcium rich foods. This percentage was similar across all sociodemographic variables. The GEE indicated that females had lower adjusted odds than males of have missing data, adjusting for other all other sociodemographic variables. No other sociodemographic variables were associated with missing outcome values.

Primary outcomes

Participants in Facebook were 1.51 times more likely to move to a higher milk category compared to those in control (Table 8.3). Similarly, those in Facebook plus text were 1.77 times more likely to move to a higher milk intake category. However, this was not significant (P= 0.4076). There was no difference in the change in calcium intake from other foods between groups over the six weeks (P=0.5686; Table 8.4). The analysis on completers only

demonstrated a significant increase in milk intake in the Facebook plus text messages group compared with control (OR 4.99; 95% CI 1.63-15.28).

Table 8.3 Change in category of the amount of milk intake from baseline to end of intervention for all participants (n= 209, using imputed dataset)

	Baseline milk intake (%)			Percent who moved to a higher milk intake category (%)	Percent increase 95% CI (%)	Odds ratio of moving to a higher milk intake category (95% CI)[a]	P value	Overall P value
	<125 mL	125-249 mL	>250 mL					
Facebook (n=65)	38.0	36.2	25.9	35.8	22.1, 49.6	1.51 (0.61, 3.75)	0.370[b]	
Facebook plus text (n=75)	27.7	40.0	32.3	41.2	29.0, 53.4	1.77 (0.74, 4.24)	0.199[b]	0.4076
Control (n=69)	37.1	30.3	32.2	28.1	15.8, 40.4	Reference	-	

[a]Covariates appearing in the logistic regression model have been adjusted for gender, SEIFA, cooking frequency, baseline calcium (except milk) intake, baseline knowledge, baseline habit, baseline motivation and baseline self-efficacy. The logistic regression model was not adjusted for baseline milk consumption due to everyone in lower category having to stay the same or increase or everyone in the higher category having to stay the same or decrease. This resulted in a zero-cell count for these baseline categories in the respective outcome (0= same or decrease, 1= increase).

[b]*P* value is comparison with control as a reference.

Table 8.4 Change in calcium intake per day in mg (excluding milk) from baseline to end of intervention using logistic regression for all participants (n= 209, using imputed dataset)

	Mean baseline intake (SE)	Mean change (SE)	P value
Facebook (n=65)	234.3 (25.0)	7.1 (39.1)	
Facebook plus text (n=75)	271.9 (33.5)	65.5 (48.4)	0.5686
Control (n=69)	226.4 (26.8)	43.0 (30.7)	

[a]Covariates appearing in the linear regression model have been adjusted for gender, SEIFA, cooking frequency, baseline milk intake, baseline calcium intake, baseline knowledge, baseline habit, baseline motivation and baseline self-efficacy.

Secondary outcomes

Changes in secondary outcomes have been reported in Table 8.5. The answers to the knowledge questions were combined together as an overall knowledge score. The change in knowledge was significant between the groups (P = 0.0004). Those in the Facebook plus text intervention arm had a greater improvement in mean score compared to Facebook and Control. No significant difference between groups was observed for motivation (P=0.7881) or self-efficacy (P= 0.3133). For habit formation, a significant group effect was observed (P= 0.0127) with Facebook plus text group having the least increase in score. The improvement in knowledge in the Facebook plus text messages was also found with completers only analysis (p=0.0397). The effect on habit formation was not shown in the completers only analysis.

8.7.4 Engagement

Facebook posts and text messages

Table 8.6 shows the engagement with Facebook posts. More participants in the Facebook plus text intervention than the Facebook intervention viewed the posts and liked them (P<0.001 for both). In the Facebook group, three participants made comments on posts while four participants commented from Facebook plus text group.

For Facebook plus text the mean number of replies from participants was 3.8 out of a maximum 21 (range 1 to 18). Of 75 participants, 12 made no reply texts (one participant gave a wrong phone number and texts could not be delivered). The highest number of replies was to the yes/no response as to whether they had set a goal on the app (n=22).

Table 8.5 Change in secondary outcomes from baseline to end of intervention for all participants (n= 209, using imputed dataset)

	Facebook		Facebook plus text		Control		P value
Outcome	Mean Baseline value (SE)	Mean change (95% CI)	Mean Baseline value (SE)	Mean change (95% CI)	Mean Baseline value (SE)	Mean change (95% CI)	
Habit formation score (out of 28)	15.7 (0.7)	3.5 (1.6, 5.3)	16.4 (0.8)	0.5 (0.93, 2.0)	15.3 (0.8)	3.4 (1.7, 5.2)	0.0127
Overall knowledge score (out of 18)	6.7 (0.3)	1.6 (0.6, 2.5)	6.3 (0.3)	2.9 (2.0, 3.8)	6.6 (0.3)	0.2 (-0.7, 1.1)	0.0004
Motivation score (out of 16)	10.4 (0.4)	1.0 (0.3, 1.7)	10.4 (0.3)	1.0 (0.3, 1.8)	10.5 (0.3)	1.1 (0.4, 1.9)	0.7881
Self-efficacy (out of 25)	19.4 (0.6)	1.2 (-0.1, 2.4)	19.5 (0.5)	0.5 (-0.8, 1.8)	17.8 (0.6)	1.0 (-0.4, 2.4)	0.3133

[a]Covariates appearing in the linear regression model have been adjusted for gender, SEIFA, cooking frequency, baseline milk intake, baseline calcium intake, baseline knowledge, baseline habit, baseline motivation and baseline self-efficacy.

Table 8.6 Engagement with the program on Facebook

Engagement recorded on Facebook per post	Facebook (mean ± SD)	Facebook plus text (mean ± SD)	P Value
Seen by	19.9 (3.6)	26.9 (5.0)	<0.001
Likes	1.1 (1.4)	3.6 (2.4)	<0.001
Comments	0.1 (0.5)	0.2 (0.9)	0.405

[a]Conducted using an independent samples t test.

8.7.5 Process evaluation

The majority of participants (n= 133) completed the process evaluation questions and Table 8.7 shows that there were no differences between intervention groups as to ease of use, their liking, likelihood of recommending it to others or usefulness of the program. Participant responses in relation to message reading and interactions are included in Appendix 8.6.

Table 8.7 Process evaluation of the CAN-DO study on intervention experience

Questions asked[a]	Facebook (n=45)	Facebook plus text (n=44)	Control (n=44)
How easy was it to follow the program?	3.80 (0.89)	3.73 (1.25)	4.0 (0.96)
How much did you like the program?	3.54 (0.89)	3.57 (1.15)	3.82 (0.92)
How likely are you to recommend it to others?	3.41 (1.03)	3.50 (1.25)	3.80 (1.02)
How useful was the program to you?	3.35 (0.98)	3.57 (1.11)	3.57 (1.10)

[a]Participants were asked to rate on a scale of 1 to 5 (5 being highest)

The thematic analysis with representative quotes is tabulated in Appendix 8.7. The themes were grouped into ease of use, raised awareness, increased intake, feedback on recipes, reasons for reading/posting and suggestions for improvement. Any comments that did not fit into these five groups were labelled as 'general feedback'. There was a divergence of opinion on the ease of use with some suggesting it was easy to follow and others had more difficulty understanding and wanted more feedback. Successful participants shared their accomplishments in achieving their goals. The feedback on the recipes was overall positive

but some admitted they never prepared any of them. The majority of respondents chose not to share posts with reasons being they were uncertain they could add anything extra to the conversation or they did not feel comfortable with sharing. Some of the suggestions for improvement under general feedback included using an alternate platform that allows for active chat between members, sending text messages more frequently to check up on their progress, completing surveys weekly to track progress and organising meetings in person. Most participants viewed the notifications as a gentle and helpful reminder while some found it intrusive.

8.8 Discussion

8.8.1 Principal Findings

This study showed that a six-week intervention to increase calcium intakes tailored to young adults delivered using a social media platform and text messages was successful in improving knowledge about calcium-rich foods. However, this did not result in a significant increase in calcium-rich food and beverage intakes. The Facebook intervention delivered alone failed to show knowledge improvement but engagement with the social media was significantly less than in the intervention arm receiving text messages and might explain the disparate finding. Other reasons for the difference might be that the additions of texts appear to provide a more personalized program and the need to reply to some messages engenders accountability and perception of monitoring by the staff delivering the intervention.

The findings of a successful outcome from the combined intervention arm concur with the earlier findings of a weight loss program delivered to overweight and obese college-aged students. Over eight weeks topics (one per week) around weight loss were posted on Facebook and the other intervention arm additionally received text messages with personalized feedback each week [20]. While our text messages were generic the participants name was included and they were written in the Generation Y tone for which young adults had previously expressed a preference [33]. The texts provided additional prompts to set goals and self-monitor their own behaviour with some further education and persuasion. These two behaviour change techniques have been demonstrated to result in behaviour change [42].

Few dietary changes occur as a result of education alone but it was indicated as a necessary antecedent to behaviour change in this demographic based on our previous focus group findings. While the Facebook plus text group improved knowledge, the overall score

remained quite low with the mean score only reaching 50% correct answers. Another barrier to improving calcium intakes seemed to stem from lack of motivation with all groups scoring similarly at baseline (10 out of 16) with uniform small improvement at end of intervention. In future programs more planning around the inclusion of other techniques to improve reflective motivation may be needed. Coercion, persuasion and incentivisation could be possible solutions [31]. Social media platforms readily offer the capacity for monitoring of an individual's behaviour by others and social comparison could be applied to intake of calcium-rich foods in this case. The vacillation might be that members are uncomfortable with sharing information with others as seen here in the replies to the process evaluation. The lack of posts made by group members is also indicative that such an approach may not work to positively influence motivation. Further research to understand what would allow participants to be relaxed with sharing dietary information in a nutrition intervention is desirable. With regards to incentivisation and rewards, an earlier qualitative study with young adults for the co-design of an intervention to improve vegetable intakes reported that self-rewards were unlikely to motivate them as it required too much self-organisation so social or material rewards may be a better choice [21].

The validity of the food frequency instrument to measure changes in the primary outcome of calcium from milk and other foods in this population must also be questioned. Any self-report tool is always subject to participant bias [43]. In addition, this tool may not possess sufficient precision to detect small changes in intakes as milk intakes are categorised in cups from half a serve of dairy to four or more serves of dairy. The calcium specific food frequency questionnaire was selected rather than other tools as the burden of completion was low but it does serve to rank individuals rather than assess absolute intake and hence the odds of increasing category of intake was used here.

Improvements in calcium intake were not achieved but the retention and engagement in the social media intervention was substantial for an electronically delivered intervention [44]. Overall, 70% of the sample was retained and more than half the participants viewed the posts. Previous studies report large attrition and declining engagement in social media interventions for improving health behaviours [45]. A strength of the CAN-DO study was the formative research conducted to inform program design and materials [33]. The components were generally well received, and the recipe videos commended.

Among the limitations of the current study was the overrepresentation of females comprising 70% but this is not uncommon in nutrition studies even when males are equally targeted. Additionally, in the case of calcium it is females who are more likely to have inadequate intakes so the population participating was appropriate. Some participants who did not do their own grocery shopping and cooked infrequently may have lessened opportunity to alter their meals and snacks. The length of the program may have been too short to see the change in knowledge translate into changes in consumption of calcium containing foods and intakes were only measured at two time points. An intervention delivered to University students that included a face-to-face session followed by text messages for ten weeks did show increases in calcium intake [46] In future a longer intervention might be appropriate. Lastly, to include the largest number of participants, multiple imputation was used. This increases the variance in the estimate and a more conservative interpretation of results than completers only analysis.

8.8.2 Conclusions

The CAN-DO study was found to be feasible to deliver in our selected target population. Our qualitative results from the process evaluation mostly indicate that participants enjoyed the program. However, the quantitative result shows that one (change in knowledge) out of five

outcomes improved in the Facebook plus text messages group only. The CAN-DO study has provided valuable insights into the process of disseminating a social media intervention for young adults and a number of changes to program design are indicated to improve motivation. The lack of interaction between the members of the groups requires research to discover how to facilitate members to post and provide social support. This is important as it appears the social interaction between the interventionist and participants via the text messages results in better outcomes.

8.9 References

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8.10 Conclusion to chapter

To our knowledge, the CAN-DO program is the first theory-based intervention to apply the COM-B framework and use social media for the delivery of a program designed to improve calcium intake of young adults. The findings presented in this chapter confirmed Facebook and text messaging to be a viable platform for health promotion. Although the program received moderate amounts of engagement, it was mostly obtained through a passive manner (likes rather than comments). The program improved knowledge and habit formation of participants but did not increase their consumption of calcium-rich foods. Further research is needed to understand how young adults can be better engaged and what resources can be offered to boost their motivation to improve their intakes. The next chapter will discuss the learnings from this body of work and key considerations for future research.

Appendix 8

Appendix 8.1 E-leaflet provided to participants in Group C

Factsheet on calcium

Calcium is an important nutrient for bone health and has a role in prevention of chronic disease and attainment of peak bone bass, 90% of which is acquired by the age of 20.[1] Dairy products like milk, yoghurt and cheese are a good source of calcium, and can also provide lots of essential nutrients such as zinc and magnesium. Dairy consumption has been found to be protective for many chronic diseases like osteoporosis, heart disease, stroke, hypertension and type II diabetes. [2-6]

Population intake

Calcium intake is low in the Australian population; particularly among adolescents as they transition into adulthood.[7, 8] According to the latest Nutrition Survey conducted by the Australian Bureau of Statistics in 2011-12, 44% of males and 71% of females in the young adult age group have inadequate calcium intakes.[9-10]

Food sources of calcium

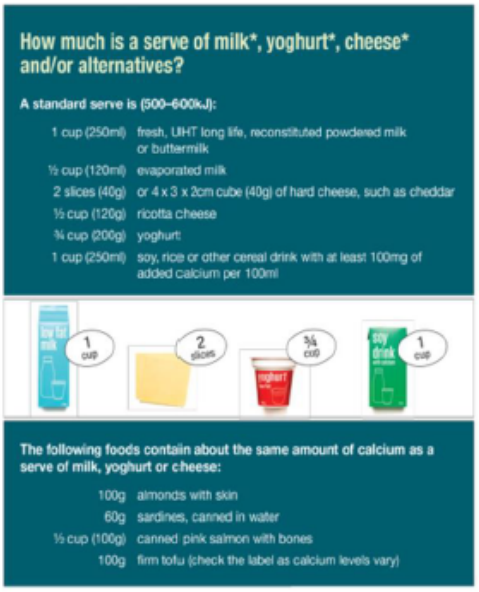
Most people know that dairy products are a good source of calcium. The Australian Guide to Healthy Eating (AGHE) recommends low or reduced fat milk, yoghurt and cheese choices for people aged two years and over.[11] The guidelines advise that more than 50% of intake from dairy foods should be reduced-fat varieties.

For people who choose not to consume dairy products, there are a wide range of alternatives available in the market. There are several other ways to get enough calcium in your diet if you choose to avoid dairy foods. The figure on the right shows what a standard serve of calcium looks like for dairy and non-dairy sources.

When choosing alternate dairy options, check the nutrition information panel to ensure they contain at least 100 mg of calcium per 100mL.

Please note that the calcium content given for the foods in this document is an approximate. This is because calcium content will vary on the method of production, label or brand.

A SERVE OF MILK, YOGHURT, CHEESE AND/OR ALTERNATIVES* IS 500-600KJ WHICH IS:



*Choose mostly reduced fat

Source: Australian Guide to Healthy Eating https://www.eatforhealth.gov.au/food-essentials/five-food-groups/milk-yoghurt-cheese-andor-their-alternatives-mostly-reduced-fat [accessed on 25th June, 2018]

Calcium content of some common foods

Foods	Standard serve	Calcium (mg/ serve)
Cheese (hard/ cheddar/ tasty)	1 slice/ 2.5 cm (16g)	124
Cheese (soft/ cheese/ cottage)	1 tablespoon (20 g)	15
Yoghurt	1 small tub (200 g)	256
Tofu firm	½ cup (125 g)	130
Sardines (canned)	5 sardines (75 g)	227
Salmon (canned)	½ cup (105 g)	326
Broccoli	½ cup (120 g)	120
Kale (steamed)	1 cup	94
Spinach/ silverbeet	½ cup (66 g)	45
Almonds	30 g	75

How much calcium do I need to eat? The amount of calcium required is different across age groups.[12]

	Age	EAR	RDI
Men	19-30 years	840 mg/ day	1000 mg/day
	31-50 years	840 mg/ day	1000 mg/day
	51-70 years	840 mg/ day	1000 mg/day
	>70 years	1100 mg/day	1300 mg/day
Women	19-30 years	840 mg/ day	1000 mg/day
	31-50 years	840 mg/ day	1000 mg/day
	51-70 years	1100 mg/day	1300 mg/day
	>70 years	1100 mg/day	1300 mg/day

Recommended Dietary Intake (RDI): the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a group.

Estimated Average Requirement (EAR): a nutrient intake value that is estimated to meet the requirement of half the healthy individuals in a group.

How do I incorporate calcium-rich foods in my diet?

Milk, yoghurt, cheese and/or alternative products are commonly consumed by Australians. There are endless ways to incorporate them in your diet. It can be as simple as a glass of milk or slice of cheese, or combining with other foods to make larger meals such as:

Meal	Ways to incorporate calcium
Breakfast	• Milk/yoghurt (or alternatives) used on cereal, in porridge, in smoothies; • Cottage cheese/ricotta cheese on wholegrain toast
Lunch	• Sliced cheese/ricotta cheese on wholegrain bread • Pasta with cheese and spinach
Dinner	• Grated and grilled cheese on top of main meal, white sauce • Fish cakes using canned salmon or sardines
Snacks	• Tub of yoghurt (or alternative), • Cold or hot milk drinks including milk-based coffees
Desserts	• Ricotta to make pancakes or cheesecake • Use low fat varieties to save on kilojoules

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Appendix 8.2 Questionnaire used to measure change in knowledge at baseline and end of intervention

Which of the following is a good source of calcium? (Can select more than one)

- ☐ Bread
- ☐ Cheese
- ☐ Cauliflower
- ☐ Broccoli
- ☐ Potato
- ☐ Soy milk
- ☐ Sardines
- ☐ Canned salmon
- ☐ Cashews
- ☐ Almonds
- ☐ Chicken
- ☐ Tofu
- ☐ Lamb
- ☐ Beef
- ☐ Yoghurt
- ☐ Lentils

What do you think is considered a serve of calcium? If you are unsure, you can make a guess.	
Milk	◯ 1/2 cup of milk (125 mL) ◯ 1 cup of milk (250 mL) ◯ 1.5 cups of milk (375 mL)
Yoghurt	◯ 50 g yoghurt ◯ 100g yoghurt ◯ 200g yoghurt (3/4 cup)
Cheese (hard)	◯ 20 g hard cheese ◯ 40 g hard cheese ◯ 50 g hard cheese
Cheese (soft)	◯ 60 g ricotta ◯ 90 g ricotta ◯ 120 g ricotta
Almonds	◯ 50 g almonds with skin ◯ 75 g almonds with skin ◯ 100 g almonds with skin
Sardines	◯ 30 g sardines, canned in water ◯ 60 g sardines, canned in water ◯ 90 g sardines, canned in water
Salmon	◯ 50 g canned pink salmon with bones (1/4 cup) ◯ 100 g canned pink salmon with bones (1/2 cup) ◯ 150 g canned pink salmon with bones (3/4 cup)
Tofu	◯ 50 g firm tofu ◯ 100 g firm tofu ◯ 150 g firm tofu

What do you think is the recommended number of serves of calcium that should be eaten IN A DAY for your age group?	◯ Less than 1.5 serves A DAY ◯ 2 serves A DAY ◯ 2.5 serves A DAY ◯ 3 serves A DAY
What do you think is the calcium requirement for your age group (young adults) in milligrams?	◯ Less than 500 mg/day ◯ Between 500- 840 mg/ day ◯ Between 840-1000 mg/day ◯ More than 1000 mg/day

Appendix 8.3: Change in the amount of milk intake from baseline to end of intervention (completers only)

	Baseline milk intake (n)			Percent who moved to a higher milk intake category (%)	Percent increase 95% CI (%)	Odds ratio of moving to a higher milk intake category (95% CI)	P value	Overall P value
	<125 mL	125-249 mL	>250 mL					
Facebook (n=45)	17	17	11	56.9	44.5, 68.5	1.73 (0.60, 5.01)	0.311	0.0180
Facebook plus text (n=42)	13	18	11	72.0	60.7, 81.1	4.99 (1.63, 15.28)	0.005	
Control (n=49)	18	15	16	49.3	37.6, 61.0	Reference	-	

†Covariates appearing in the logistic regression model have been adjusted for gender, SEIFA, cooking frequency, baseline calcium intake, baseline knowledge, habit, motivation and self-efficacy. The logistic regression model was not adjusted for baseline milk consumption due to everyone in lower category having to stay the same or increase or everyone in the higher category having to stay the same or decrease. This resulted in a zero-cell count for these baseline categories in the respective outcome (0= same or decrease, 1= increase).

Appendix 8.4 Change in calcium intake per day in mg (excluding milk) from baseline to end of intervention (completers only)

	Mean baseline intake (SE)	Mean change (SE)	95% CI	P value
Facebook (n=16)	264.2 (38.5)	1.6 (35.7)	-70.0, 73.2	
Facebook plus text (n=14)	234.9 (61.8)	63.3 (34.9)	-6.7, 133.4	0.9188
Control (n=22)	256.4 (35.8)	22.1 (41.3)	-60.8, 104.9	

†Covariates appearing in the linear regression model have been adjusted for gender, SEIFA, cooking frequency, baseline milk intake, baseline calcium intake, baseline knowledge, baseline habit, baseline motivation and baseline self-efficacy.

Appendix 8.5 Change in secondary outcomes from baseline to end of intervention (completers only)

	Facebook (n=45)		Facebook plus text (n=45)		Control (n=50)		P value
Outcome	Mean Baseline value (SE)	Mean change (95% CI)	Mean Baseline value (SE)	Mean difference (95% CI)	Mean Baseline value (SE)	Mean difference (95% CI)	
Habit formation score (out of 28)	16.2 (0.8)	3.4 (1.6, 5.2)	16.1 (0.9)	1.1 (-0.5, 2.6)	16.1 (0.9)	3.4 (1.9, 4.9)	0.2238
Overall knowledge score (out of 18)	6.9 (0.3)*	1.6 (0.7, 2.5)	6.3 (0.3)	3.0 (1.9, 4.1)	6.7 (0.3)	0.26 (-0.7, 1.2)	0.0397
Motivation score (out of 16)	10.5 (0.4)	1.1 (0.4, 1.8)	10.5 (0.4)*	1.4 (0.6, 2.1)	10.5 (0.3)*	1.3 (0.5, 2.0)	0.7805
Self-efficacy (out of 25)	19.9 (0.6)	1.2 (0.1, 2.3)	19.4 (0.6)*	1.0 (-0.2, 2.3)	17.6 (0.7)*	1.7 (0.3, 3.1)	0.1320

†Covariates appearing in the linear regression model have been adjusted for gender, SEIFA, cooking frequency, baseline milk and calcium intake, baseline knowledge, habit, motivation and self-efficacy. * indicates data missing from one participant.

Appendix 8.6 Process evaluation of the CAN-DO study on frequency of reading posts, messages and interaction

Questions	Frequency	Facebook (n=46)	Facebook plus text (n=44)
How often did you read the text messages?	All the time	Not applicable for this group as they were not sent any text messages	35
	More than once a week		7
	Less than once a week		0
	Rarely		2
	I did not receive any text messages		0
How often did you read the Facebook posts?	All the time	10	20
	More than once a week	17	11
	Less than once a week	7	7
	Rarely	6	3
	I did not see any Facebook posts	6	3
Did you share your own content in the Facebook group?	Yes	0	4
	No	37	38
	I was not included in a Facebook group	9	2

Appendix 8.7 Quotations illustrating feedback from participants provided through text message replies and qualitative process evaluation (n= 106)

Themes	Supporting quotes
Goal-setting	"Goal is two weeks without missing a day, so far on track!" (female, Facebook plus text)
	"Yes I achieved my goals today"(female, Facebook plus text)
	"Yes, I have achieved my personal goals of having Greek yoghurt/ some sort of milk or calcium added to my breakfast and lunch everyday" (female, Facebook plus text)
Demonstrates improvement in intake	"Life has been so busy for me at the moment but I have been remembering to eat yoghurt and that's nice" (female, Facebook plus text)
	"…more mindful of my calcium intake and having a little more each day"; (female, Facebook plus text)
	"I remembered to buy strawberry Yoplait yoghurt and started drinking milk today so that was nice" (female, Facebook plus text)
	"Yes I have achieved my personal goal of the having Greek yoghurt/ some sort of milk or calcium added into my breakfast and lunch everyday" (female, Facebook plus text)
	"Already picked up plenty of yoghurt and some cheese this week" (female, Facebook plus text)
	"I have been consuming approximately 2-3 serves of calcium per day since beginning of this study. It has really opened my eyes to foods which are calcium rich that I was unaware of, such as tofu and some fish" (female, Facebook plus text)
Ease of use	"The survey was very easy to use.." (female, Facebook)
	"It didn't feel very interactive" (female, Facebook)
	"More instructions could have made the study clearer" (female, Facebook plus text)
	"The program was easy to follow, but I noticed people were confused as to what they were doing, as the amount of participation was variable" (male, Facebook plus text)
Raised awareness	"For myself, I feel much more knowledgeable in this area than before, as before I wouldn't even know the recommended intake or which foods are high in calcium" (female, Facebook plus text)
Feedback on recipes	"Showing recipes made it so much easier and more fun than just reading listed foods" (female, Facebook)
	"The recipes were pointless. The picture with the serve info was the only information I cared about" (male, Facebook plus text)
	"I wasn't trying the recipes but I thought they were great, planning to try some in the future" (female, Facebook plus text)
	"The breakfast smoothie idea is now a staple!" (female, Facebook plus text)
	"I loved the recipes and shared them with my family" (female, Facebook plus text)
Reason for reading text	"The text messages were a good way to be reminded to check my calcium intake" (male, Facebook plus text)

messages	"They were relevant and interesting" (female, Facebook plus text)
	"It was good to have an instant reminder to check my habits or provide ideas" (female, Facebook plus text)
Reason for not sharing content	"I don't like to share on Facebook" (female, Facebook)
	"I'm reluctant to share information online" (female, Facebook)
	"I'm more of a passive participant, I did watch some videos but didn't feel like posting anything" (female, Facebook)
	"I would have if it was anonymous" (female, Facebook plus text)
	"I didn't feel comfortable including my own ideas. I did appreciate when someone else posted though" (female, Facebook plus text)
Overall feedback and suggestions for improvement	"I think if it was on another site (i.e. not Facebook), I would go on it more often (I rarely use Facebook). Also, if there was an active chat with all the members talking and posting pictures it would be more fun and interesting." (female, Facebook)
	"The constant texts and notifications are kind of annoying. Perhaps there could be a less intrusive way of providing the information." (female, Facebook plus text)
	"Lots of the meals worked and were delicious! I will definitely keep using the app and still follow the page if possible" (female, Facebook plus text)
	"Thanks for the study, it really helps me realise how much calcium I was lacking and keep me in track with my calcium consumption." (female, Facebook plus text)
	"Loved all the recipes and all the tips, definitely will increase the calcium in my diet after this!" (female, Facebook plus text)
	"The study has really opened my eyes to calcium rich foods that I didn't expect to be calcium rich, such as tofu and sardines. The recipes were delicious and easy to make, and a great initiative to encourage myself to increase my calcium". (female, Facebook plus text)

Appendix 8.8 Ethical approval for conducting the RCT with young adults

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
Human Research Ethics Committee

Friday, 24 August 2018

Prof Margaret Allman-Farinelli
School of Life and Environmental Sciences (SOLES); Faculty of Science
Email: margaret.allman-farinelli@sydney.edu.au

Dear Margaret

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

After consideration of your response to the comments raised your project has been approved.

Approval is granted for a period of four years from **24 August 2018** to **24 August 2022**

Project title: **Improving calcium intake in young adults: a six-week randomised controlled trial**

Project no.: **2018/597**

First Annual Report due: **24 August 2019**

Authorised Personnel: **Allman-Farinelli Margaret; Davies Alyse; Rouf Anika; Hayba Nematullah; Nour Monica;**

Documents Approved:

Date Uploaded	Version number	Document Name
16/08/2018	Version 2	PIS clean version
16/08/2018	Version 2	Screening questionnaire_clean version
02/07/2018	Version 1	Face-to-face recruitment script
02/07/2018	Version 1	Baseline and end of intervention questionnaire
02/07/2018	Version 1	Email to lecturers
02/07/2018	Version 1	Overview of intervention and sample posts
02/07/2018	Version 1	Participant flow diagram
02/07/2018	Version 1	Recruitment poster
02/07/2018	Version 1	E-leaflet on calcium
02/07/2018	Version 1	Social media recruitment
02/07/2018	Version 1	Email to previous research participants

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:

Research Integrity & Ethics Administration
Level 2, Margaret Telfer Building (K07)
The University of Sydney
NSW 2006 Australia

T +61 2 9036 9161
E human.ethics@sydney.edu.au
W sydney.edu.au/ethics

ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

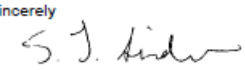
- Serious or unexpected adverse events (which should be reported within 72 hours).
- Unforeseen events that might affect continued ethical acceptability of the project.

- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely



Associate Professor Stephen Assinder
Chair
Human Research Ethics Committee (HREC 1)

The University of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007) and the NHMRC's Australian Code for the Responsible Conduct of Research (2007).

Appendix 8.9 Recruitment poster

Appendix 8.10 Participant Information Statement

THE UNIVERSITY OF SYDNEY

Discipline of Nutrition and Dietetics
School of Life and Environmental Sciences
Faculty of Science

ABN 15 211 513 464

Margaret Allman-Farinelli
Professor of Dietetics

Level 4 East
Charles Perkins Centre D17
The University of Sydney
NSW 2006 AUSTRALIA
Telephone: +61 2 9036 7045
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Email: margaret.allman-farinelli@sydney.edu.au
Web: http://www.sydney.edu.au/

Improving calcium intake in young adults: a six-week randomised controlled trial

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

We want to help young adults eat more calcium-rich foods as National Nutrition Surveys indicate that young adults do not consume enough. Calcium is an important nutrient for bone health and has been found to be protective against chronic diseases, such as heart disease, high blood pressure, type II diabetes and obesity.

You are invited to take part in a six-week electronic study to enable young adults to eat more calcium-rich foods. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary. By giving your consent to take part in this study you are telling us that you:

- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

You will be able to save a copy of the Participant Information Statement. If you wish to keep a copy for your records, make sure to save this PDF on your computer.

(2) Who is running the study?

The study is being carried out by the following researchers:

- Margaret Allman-Farinelli, Professor of Dietetics
- Anika Rouf, PhD Candidate
- Alyse Davies, PhD Candidate
- Nematullah Hayba, PhD Candidate
- Monica Nour (Research Assistant)

Anika Rouf is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney. This will take place under the supervision of Professor Margaret Allman-Farinelli.

(3) What will the study involve for me?

Eligible participants will be asked to complete two surveys (one baseline survey before joining the program and one after six weeks). Some participants may be invited to receive social media posts or text messages.

(4) How much of my time will the study take?

The baseline and final survey will each take approximately 10 to 15 minutes to complete. The study will run for six weeks. The time for those who participate in the social media posts and text messages will be about 5 to 10 minutes each day.

(5) Who can take part in the study?

Young adults (males and females) aged 18-25 years owning a smartphone and a Facebook account and not completing or completed a nutrition related degree can take part in this study. Participants who have completed a nutrition course or those currently undertaking a nutrition course will be excluded as their nutrition knowledge would be more than that of an average young adult. Any participants with a food allergy or known lactose intolerance will be excluded. Any participants currently taking calcium supplements (but not multivitamins) or eating disorders will be excluded.

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at The University of Sydney. You are allowed to withdraw in the middle of completing the questionnaire if you are not comfortable answering the questions. However, if you withdraw from the study prior to completing the final questionnaire, you will not be eligible to receive an e-voucher.

(7) Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study. Participation in this study should involve no physical or mental discomfort. If, however, you should find any questions to be offensive or invasive, you are free to withdraw from answering the survey questions.

(8) Are there any benefits associated with being in the study?

We cannot guarantee that you will receive any direct benefits from being in the study. You may gain some health information from viewing the social media posts or text messages. You will receive a $10 Coles e-voucher once you have completed the final questionnaire. However, if you drop out prior to completion of the final questionnaire, you will not be able to eligible for the voucher.

(9) What will happen to information about me that is collected during the study?

All data collected in this study will be stored confidentially (with the exception of your Facebook account which may be visible to other participants taking part in the program). As some participants may be invited to join a closed Facebook group, your Facebook account will be visible to other members who are taking part in this program. However, you are more than welcome to create a separate Facebook account exclusively for this program which is not your legal identifiable name.

All information collected through the surveys will be held confidential and only members of the research team will have access to identified data. Your information will be stored securely and your identity/information will be

kept strictly confidential, except as required by law. Study findings may be published, but you will not be individually identifiable in these publications.

By providing your consent, you are agreeing to us collecting personal information, such as age and gender, about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

(10) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?

When you have read this information, Anika Rouf (arou9270@uni.sydney.edu.au) will be available to discuss it with you further and answer any questions you may have.

(12) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell us that you wish to receive feedback by emailing Anika Rouf (arou9270@uni.sydney.edu.au). This feedback will be in the form of a one-page summary and can be sent after the study is finished.

(13) What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney *[INSERT* protocol number once approval is obtained*]*. As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- ✓ **Telephone:** +61 2 8627 8176
- ✓ **Email:** human.ethics@sydney.edu.au
- ✓ **Fax:** +61 2 8627 8177 (Facsimile)

This information sheet is for you to keep

Appendix 8.11 Screenshots of the questionnaire administered on REDCap

Confidential

Screening questionnaire

The CAN-DO study is testing a 6-week program which is designed to help you eat more calcium-rich foods. Calcium is an important nutrient for bone health and has been found to be protective against chronic diseases, such as heart disease, high blood pressure, type II diabetes and obesity.

By completing this screener online, you are giving your consent to be screened. You should read the full Participant Information Statement (PIS) before proceeding.

[Attachment: "Participant Information Statement.pdf"]

Are you aged between 18 to 25 years?
◯ Yes
◯ No

Sorry, you do not meet the criteria for our study. Please find advice on healthy eating in the attached document "The Australian Guide to Healthy Eating". Thank you for your interest.

[Attachment: "Australian_guide_to_healthy_eating.pdf"]

Have you studied or are you currently studying nutrition or nutrition related subjects?
◯ Yes
◯ No

Sorry, you do not meet the criteria for our study. Please find advice on healthy eating in the attached document "The Australian Guide to Healthy Eating". Thank you for your interest.

[Attachment: "Australian_guide_to_healthy_eating.pdf"]

Do you have a food allergy or lactose intolerance?
◯ Yes
◯ No

Sorry, you do not meet the criteria for our study. Please find advice on healthy eating in the attached document "The Australian Guide to Healthy Eating". Thank you for your interest.

[Attachment: "Australian_guide_to_healthy_eating.pdf"]

Have you ever been diagnosed with, or treated for any eating disorders?
◯ Yes
◯ No

Sorry, you do not meet the criteria for our study. Please find advice on healthy eating in the attached document "The Australian Guide to Healthy Eating". Thank you for your interest.

[Attachment: "Australian_guide_to_healthy_eating.pdf"]

Are you currently taking calcium supplements?
◯ Yes
◯ No

Sorry, you do not meet the criteria for our study. Please find advice on healthy eating in the attached document "The Australian Guide to Healthy Eating". Thank you for your interest.

[Attachment: "Australian_guide_to_healthy_eating.pdf"]

Do you own a smartphone and have a personal Facebook account?
◯ Yes
◯ No

projectredcap.org REDCap

Sorry, you do not meet the criteria for our study. Please find advice on healthy eating in the attached document "The Australian Guide to Healthy Eating". Thank you for your interest.

[Attachment: "Australian_guide_to_healthy_eating.pdf"]

What type of phone do you use?

- ◯ iPhone (Apple)
- ◯ Android (includes Motorola, HTC, Samsung, Sony Ericsson and other non-Apple phones)

Based on the screener, you are eligible to participate in this study. Please review the Participant Information Statement and provide your consent to progress to the questionnaire. After this, you will receive an email with a link to our program.

PARTICIPANT CONSENT FORM
By proceeding with this questionnaire, you agree and give consent to take part in this study
In giving your consent you state that:
• You understand the purpose of the study, what you will be asked to do, and any risks/benefits involved.
• You have read the study information sheet and have been able to discuss your involvement in the study with the researchers if you wished to do so.
• The researchers have answered any questions you had about the study and you are happy with the answers.
• You understand that being in this study is completely voluntary and you do not have to take part. Your decision whether to be in the study will not affect your relationship with the researchers or anyone else at the University of Sydney, now or in the future.
• You understand that you can withdraw from the study at any time. However, if you withdraw before completing the final questionnaire, you will not be eligible for the reimbursement voucher.
• You also understand that it will not be possible to withdraw answers from the questionnaires once they have been submitted.
• You understand that personal information about you that is collected over the course of this project will be stored securely and will only be used for purposes that you have agreed to. You understand that information about you will only be told to others with my permission, except as required by law.
• You understand that personal information about you that is collected over the course of this project may be provided to third parties for use in research, for which ethical approval will be sought, and that all identifying information will be removed, so that the third party will not know whose information it is.
• You understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about you.

Please indicate whether you consent to the following to continue with the questionnaire:
Do you consent to participating in this 6-week program?

- ◯ Yes
- ◯ No

Do you consent to being contacted for a follow up 10-minute phone interview to share your thoughts on the program?

- ◯ Yes
- ◯ No

Thank you for providing you consent. Please complete the following

First Name _____

Email address _____

Contact number _____

Age	◯ 18 ◯ 19 ◯ 20 ◯ 21 ◯ 22 ◯ 23 ◯ 24 ◯ 25
Gender	◯ Male ◯ Female ◯ Other ◯ Prefer not to say
Postcode	_____
Occupation	◯ Student ◯ Full-time work ◯ Part-time or casual work ◯ Unemployed
In what field do you work/study?	◯ Education ◯ Office support ◯ Healthcare ◯ Management ◯ Finance ◯ Food service industry ◯ Information Technology ◯ Building, Design or Construction ◯ Other
Please specify the 'other' industry you work/study in.	_____
What is the highest level of education that you have completed?	◯ Year 10 or below ◯ Year 12 ◯ Certificate or Diploma ◯ Bachelor or Postgraduate Degree ◯ Prefer not to say
What is the total of all wages/salaries, government benefits/allowances and other income that you usually receive?	◯ Nil or negative income ◯ $1 - $499 per week ($1- $25,999 per year ◯ $500- $999 per week ($26,000 - $51,999 per year) ◯ $1,000 - $1,499 per week ($52,000 - $77,999 per year) ◯ $1,500 - $1,999 per week ($78,000 - $103,999 per year) ◯ $2,000 or more per week ($104,000 or more per year) (NOTE: do not deduct: tax, superannuation contributions, health insurance, or any other automatic deductions.)
Who purchases the main groceries in your household?	◯ Myself ◯ My Partner ◯ My Parents ◯ My housemate/s

Age	◯ 18 ◯ 19 ◯ 20 ◯ 21 ◯ 22 ◯ 23 ◯ 24 ◯ 25
Gender	◯ Male ◯ Female ◯ Other ◯ Prefer not to say
Postcode	_____
Occupation	◯ Student ◯ Full-time work ◯ Part-time or casual work ◯ Unemployed
In what field do you work/study?	◯ Education ◯ Office support ◯ Healthcare ◯ Management ◯ Finance ◯ Food service industry ◯ Information Technology ◯ Building, Design or Construction ◯ Other
Please specify the 'other' industry you work/study in.	_____
What is the highest level of education that you have completed?	◯ Year 10 or below ◯ Year 12 ◯ Certificate or Diploma ◯ Bachelor or Postgraduate Degree ◯ Prefer not to say
What is the total of all wages/salaries, government benefits/allowances and other income that you usually receive?	◯ Nil or negative income ◯ $1 - $499 per week ($1- $25,999 per year ◯ $500- $999 per week ($26,000 - $51,999 per year) ◯ $1,000 - $1,499 per week ($52,000 - $77,999 per year) ◯ $1,500 - $1,999 per week ($78,000 - $103,999 per year) ◯ $2,000 or more per week ($104,000 or more per year) (NOTE: do not deduct: tax, superannuation contributions, health insurance, or any other automatic deductions.)
Who purchases the main groceries in your household?	◯ Myself ◯ My Partner ◯ My Parents ◯ My housemate/s

On average, how many times a week do you cook?	◯ 0 times per week ◯ 1-2 times per week ◯ 3-4 times per week ◯ 5 or more times per week
How would you rate your own cooking skills?	very poor — average — very good *(Place a mark on the scale above)*

Which of the following is a good source of calcium? (Can select more than one)

- ☐ Bread
- ☐ Cheese
- ☐ Cauliflower
- ☐ Broccoli
- ☐ Potato
- ☐ Soy milk
- ☐ Sardines
- ☐ Canned salmon
- ☐ Cashews
- ☐ Almonds
- ☐ Chicken
- ☐ Tofu
- ☐ Lamb
- ☐ Beef
- ☐ Yoghurt
- ☐ Lentils

What do you think is considered a serve of calcium? If you are unsure, you can make a guess.	
Milk	◯ 1/2 cup of milk (125 mL) ◯ 1 cup of milk (250 mL) ◯ 1.5 cups of milk (375 mL)
Yoghurt	◯ 50 g yoghurt ◯ 100g yoghurt ◯ 200g yoghurt (3/4 cup)
Cheese (hard)	◯ 20 g hard cheese ◯ 40 g hard cheese ◯ 50 g hard cheese
Cheese (soft)	◯ 60 g ricotta ◯ 90 g ricotta ◯ 120 g ricotta
Almonds	◯ 50 g almonds with skin ◯ 75 g almonds with skin ◯ 100 g almonds with skin
Sardines	◯ 30 g sardines, canned in water ◯ 60 g sardines, canned in water ◯ 90 g sardines, canned in water
Salmon	◯ 50 g canned pink salmon with bones (1/4 cup) ◯ 100 g canned pink salmon with bones (1/2 cup) ◯ 150 g canned pink salmon with bones (3/4 cup)
Tofu	◯ 50 g firm tofu ◯ 100 g firm tofu ◯ 150 g firm tofu

What do you think is the recommended number of serves of calcium that should be eaten IN A DAY for your age group?	◯ Less than 1.5 serves A DAY ◯ 2 serves A DAY ◯ 2.5 serves A DAY ◯ 3 serves A DAY
What do you think is the calcium requirement for your age group (young adults) in milligrams?	◯ Less than 500 mg/day ◯ Between 500- 840 mg/ day ◯ Between 840-1000 mg/day ◯ More than 1000 mg/day

Please indicate how much you AGREE with the following statements (1=DISAGREE, 7=AGREE)							
	1 (Disagree)	2	3	4	5	6	7 (Agree)
Eating calcium-rich foods is something I do automatically	○	○	○	○	○	○	○
Eating calcium-rich foods is something I do without having to consciously remember	○	○	○	○	○	○	○
Eating calcium-rich foods is something I do without thinking	○	○	○	○	○	○	○
Eating calcium-rich foods is something I start doing before I realise I'm doing it	○	○	○	○	○	○	○

Please rate how CONFIDENT you are to do the following: 1=Not Confident At All, 5=Very Confident					
	1 (Not confident at all)	2	3	4	5 (Very confident)
I can keep calcium-rich foods at hand/readily available	○	○	○	○	○
I can eat the recommended number of serves of calcium-rich foods when I eat on my own	○	○	○	○	○
I can shop for a variety of calcium-rich foods	○	○	○	○	○
I can make time to eat more calcium-rich foods	○	○	○	○	○
When I eat at home, I can eat more calcium-rich foods	○	○	○	○	○

Please select how true the following statements are as they relate to you. (1=Very UNTRUE, 4=Very TRUE) I would try to eat more calcium-rich foods because...				
	1. Very untrue	2. Not true	3. A little true	4. Very TRUE
Eating calcium-rich foods helps me feel better	○	○	○	○
Eating calcium-rich foods is an important thing for me to do	○	○	○	○
I would feel bad about myself if I didn't	○	○	○	○
Others want me to eat more calcium-rich foods	○	○	○	○

Please indicate the type and quantity of milk consumed each day

What type of milk do you usually consume?

- ☐ Whole or regular milk
- ☐ Reduced fat milk
- ☐ Skim milk
- ☐ Soy milk
- ☐ Other plant-based (rice, oat or almond milk)
- ☐ Goat's milk
- ☐ Buttermilk
- ☐ Evaporated
- ☐ None

How much milk do you consume each day?

- ○ None
- ○ Less than 125 mL (< ½ cup)
- ○ 125-249 mL (1/2 -1 cup)
- ○ 250-499 mL (1-2 cups)
- ○ 500-999 mL (2-4 cups)
- ○ 1 or more litres

Please indicate how many standard serves (e.g. 0, 0.5, 1, 1.5, 2) of each food you usually have per week. The standard serves are listed below next to each food. You can leave a row blank if it doesn't apply to you.	
Muesli (not toasted) Standard serve = ½ cup (60 g)	_____
Rolled oats (cooked) Standard serve: 1 cup (260 g)	_____
All Bran Standard serve: ½ cup (35 g)	_____
Branflakes- Special K Standard serve: 1 cup (30 g)	_____
Sweet/ dry biscuits Standard serve: 1 biscuit (15 g)	_____
Chocolate biscuits Standard serve: 1 biscuit (15 g)	_____
Cake Standard serve: 1 slice (40 g)	_____
Bread (white/ brown/ wholemeal/ mixed grain) Standard serve: 1 slice (30 g)	_____
Bread (light/ dark rye) Standard serve: 1 slice (30 g)	_____
Cheese (hard/ cheddar/ tasty) Standard serve: 1 slice/ 2.5 cm (16g)	_____
Cheese (soft/ cheese/ cottage) Standard serve: 1 tablespoon (20 g)	_____
Yoghurt Standard serve: 1 small tub (200 g)	_____
Fruche Standard serve: 1 small tub (100 g)	_____
Ice cream Standard serve: 1 scoop (27 g)	_____
Eggs Standard serve: 1 medium (48 g)	_____
Tofu firm Standard serve: ½ cup (125 g)	_____
Sardines (canned) Standard serve: 5 sardines (75 g)	_____

Salmon (canned) Standard serve: ½ cup (105 g)	_____
Tuna (canned) Standard serve: ½ cup (100 g)	_____
King prawns (cooked) Standard serve: 6 prawns (95 g)	_____
Scallops Standard serve: 5 or 6 scallops (90 g)	_____
White fish Standard serve: 1 medium fillet (120 g)	_____
Spinach/ silverbeet Standard serve: ½ cup (66 g)	_____
Dried fruit Standard serve: 1 tablespoon (15 g)	_____
Peanuts Standard serve: ¼ cup (40 g)	_____
Orange juice Standard serve: 1 large glass (200 mL)	_____
Wine (red/ white) Standard serve: 1 glass (120 mL)	_____
Beer (regular) Standard serve: 1 glass (200 mL)	_____
Champagne Standard serve: 1 glass (150 mL)	_____

Thank you for completing this questionnaire. You will shortly receive an email from us informing you of the next steps to join the program.

Appendix 8.12 Facebook Pinned post for Group A and B

–PLEASE READ IF YOU ARE NEW MEMBER–

Hi everyone!

My name is Anika. I am a dietitian and will be posting recipes and tips to help you achieve your goal to eat more calcium-rich foods. Please keep your notifications on OR check in every alternate day for the new posts.

Calcium is an essential nutrient to keep our heart, muscles, blood, nerves and bones healthy. We achieve our peak bone mass in our early 20's. So, think calcium now for better health ahead!

Whenever you want to build a 'healthy' habit, you need to set a goal. Download the free apps 'Productive' (for iPhones) OR 'Loop Habit Tracker' (for Androids).

Now it's time to set that goal. Have a look at our group cover photo to see how many serves of calcium are required a day. If you are falling short, set a goal to increase by one serve per day.

If you have any questions, feel free to contact me by commenting on the post or sending me a DM.

For more information about calcium, please refer to the links located in the description/ info box.

Did you make it all the way to the bottom? Make sure to give this a thumbs up if you did ☺

Links to additional resources

Please see links to additional resources

https://www.nrv.gov.au/nutrients/calcium

https://www.betterhealth.vic.gov.au/health/healthyliving/calcium

https://daa.asn.au/smart-eating-for-you/smart-eating-fast-facts/nourishing-nutrients/why-do-we-need-calcium/

https://www.osteoporosis.org.au/sites/default/files/files/oa_medical_calcium_2nd_ed.pdf

https://www.dietitians.ca/getattachment/f739d485-d113-4a46-8122-eb2d33730c64/FACTSHEET-Food-Sources-of-Calcium.pdf.aspx

Appendix 8.13 Text messages sent to CAN-DO participants (Group B)

Day	Text messages
1	Hi [insert name], it's Anika from the CAN-DO program. We are so excited to have you on board for the next 6 weeks. Have you joined our group on Facebook? (Check your email for the link)
3	Hi [insert name], it's Anika from the CAN-DO program. It's time to set your goals and start tracking! Have you downloaded your app and set a goal? Please reply to this message by typing YES or NO
5	Hi [insert name], it's Anika from the CAN-DO program. Did you check out the Facebook post yesterday? Give us a thumbs up if you like it 👍🏻
7	Hi [insert name], it's Anika from the CAN-DO program. How's that calcium going? Text me 'YES' if you made that goal today!
9	Hi [insert name], Monitoring your progress can be useful when trying to establish new habits. Use an app to track your intake!
11	Hi [insert name], Have you tried tzatziki? It's a yoghurt based dip. You can use it on sandwiches (instead of mayo) or on baked potatoes (instead of sour cream).
13	Hi [insert name], Have you achieved the goal you set for yourself? If you've reached your target, challenge yourself with a new goal.
15	Hi [insert name], Want to up that calcium? Grab a yoghurt snack today.
17	Hi [insert name], Some canned varieties of fish with bones like salmon and sardines are a great source of calcium. Stock your pantry with canned fish for a quick calcium-rich sandwich filler
19	Hi [insert name], Did you know that calcium is important for your bone strength? To up the calcium, why not try anchovies and vegetables on your pizza.
21	Hi [insert name], Did you meet your goal this week? Please reply to this message by typing YES or NO.
23	Hi [insert name], Craving a sweet fix? Making a healthy choice is easier when you stock your fridge with nutritious snacks like yoghurt. Don't forget to write yoghurt on your shopping list!
25	Hi [insert name], Research shows that having calcium at breakfast increases your chance of meeting your requirement. Did you have your breakfast today? Reply YES or NO
27	Hi [insert name], Did you meet your goals? If you haven't had a chance to set your goals, it's not too late. You can use the app to track your intake!
29	Hi [insert name], How much calcium are you having now? Even if you've only increased a little, WELL DONE! You're on your way to healthier habits.
31	Hi [insert name], Do you get afternoon munchies? Why not swap those chips with some wholegrain crackers and cheese? Cheese is a great source of calcium and protein, and will help you beat the 3pm slump.

33	Hi [insert name], How are you going with your goal this week? Don't forget to grab some calcium-rich foods when you are at the supermarket!
35	Hi [insert name], Are you still using the app to track your goals? Please reply to this message by typing YES or NO.
37	Hi [insert name], Busy and need a quick meal? A veggie and cheese omelette goes down well any time of the day!
39	Hi [insert name], Have you tried any of the recipes from the cooking videos we've shared so far? Please reply to this message by typing YES or NO.
41	Hi [insert name], You've made it to the end of the 6 week CAN-DO program! If you're still working on getting your 2.5 serves of calcium, you can keep using the app to track your intake!

Appendix 8.14 Facebook posts shared with CAN-DO participants (Group A and B)

(see next page)

Day	Message	Media to attach
2	Need a sweet fix? We've got you covered. This recipe has used ricotta which is a good source of calcium, perfect for a weekend brunch! Check it out and share a pic with us if you try it at home.	Ricotta pancakes video
4	Male and females aged between 18 to 30 years should aim to consume about 1000 mg or 2.5 serves of dairy and/or alternatives per day. How much are you having? Check out this infographic which shows examples of what counts as a serve and set yourself a goal to have one more serve per day.	Post infographic 1
6	Did you know that calcium is more concentrated in dairy products than most other food groups, and is more easily absorbed? Check out this calcium-rich chocolate mousse made with low fat ricotta cheese and almonds. Yummy desserts can be good for you too!	Chocolate Mousse video
8	Research has shown that eating breakfast improves your cognitive function and memory. If you are not a breakfast eater, it's time to change and look after yourself! Here's an overnight chia pudding recipe for you to try.	Chia pudding video
10	Have you jumped on the granola bandwagon yet? This quick and easy recipe will make breakfasts a breeze. PS- if you're worried about milk spoilage, you can buy smaller (600 mL or 1L) cartons.	Granola video
12	Are you in a rush and skipping breakfast most mornings? Research shows that having calcium at breakfast increases your chance of meeting your requirements. Why not start planning your breakfast the night before or whip together a quick smoothie with milk or yoghurt?	Post infographic 2
14	Have you tried tofu? It is a great alternative to eggs and can be scrambled together with leftover veggies for breakfast. PS: Do you have any breakfast ideas you'd like us to share? Let us know what recipes you have tried in the comments below :)	Breakfast scramble video
16	Not only is fish great for heart health, but some varieties are a good source of calcium. You can opt for canned options such as salmon or sardines that will save you time and money. Check out this salmon cannelloni recipe for a delicious way to cook with canned fish.	Vegetarian and salmon cannelloni video
18	Who here has tried sardines? Even if you weren't a fan before, try this recipe and You'll be surprised how great it tastes. Don't forget to share your photo and let us know what you think :) TIP: To save some $$$, you can bulk buy canned fish when they are on sale and store them in your pantry.	Sardine fish cakes video
20	Love Tacos? We've been creative and swapped meat for canned salmon which is not only a source of omega-3s	Fish Tacos video

	but will also give you a boost of calcium.	
22	Tofu is a great plant-based source of calcium. In this recipe, we've combined it with kale, which also contains some calcium. Yoghurt can be used to bump up the calcium, but it is optional. Watch the video, have a go and share your picture with us in the comments :)	Chilli scramble video
24	Have you ever tried tzatziki? It's a yoghurt based dip. There are so many ways you can enjoy it like Sauce for meat/ fish / falafel On burgers / pita wraps On sandwiches (a healthier alternative to mayo) With baked potatoes (a healthier alternative to sour cream) As a veggie dip, salad dressing TIP: to save $$$, buy yoghurt in bulk and then share with a friend because sharing is caring!	Tzatziki video
26	It is important to get your calcium everyday as it can lower your risk of chronic diseases. Here's a photo of a veggie platter I created recently. I used the Tzatziki recipe shared on [insert day] as a side dip to boost the flavour. Make sure you give this a go and share your veggie platter with us :)	Photo of veggie platter
28	Calcium intake is low in the Australian population. 44% of males and 71% of females aged 18-30 years don't get enough. Monitoring your progress can be useful when trying to establish new habits. You can use the app 'Productive- Habit tracker' (for iPhones) and 'Loop Habit Tracker' (for Android) to track your intake.	Post infographic 3
30	For the meat lovers in this group, here's a MUST try recipe that includes mint yoghurt for some added calcium. Red meat is also a good source of iron but is best eaten in moderation. If you're a meat lover, let us know in the comments below.	Lamb steak and mint yoghurt video
32	Did you know that low fat dairy products have just as much as calcium as regular varieties? The Australian Dietary Guidelines advise that more than 50% of intake from dairy foods should be reduced-fat varieties. Check out this infographic!	Post infographic 4
34	Next time you're cooking up a stir fry, why not throw in some tofu, spinach and kale for added calcium? The calcium is a little less concentrated in these non-dairy alternatives, so it's best to combine them in a meal to get a serve in.	Post infographic 5
36	Need some meal prep inspiration? Here is a Mac and Cheese recipe you could try at home. Having pre-prepared meals in your fridge will help you avoid the temptation of take-away and keep you on track with healthy eating. TIP: to save time, you can use multiple containers to store so it is ready to grab and go for the next day!	Mac N Cheese video

38	Are you on a budget and looking to save money? Creating a shopping list will help you avoid unnecessary purchases and reduce food waste. We'll get you started with a shopping list for this delicious pasta dish: Fettucine Garlic Olive oil Low fat ricotta cheese Low fat milk Pepper Spinach Parmesan (optional)	Spinach and ricotta fettucine video
40	If you live out of home and find your dairy products expire before you make your way through them, try purchasing a smaller size (i.e. smaller milk cartons) or look for new ways to use them in your cooking. Here are some ideas of what to do with leftover ricotta cheese.	Post infographic 6
42	Is takeaway your go-to for work lunch? Try cooking larger amounts at dinner and taking the leftovers the next day for a healthier alternative. These delicious stuffed capsicums contain ricotta and parmesan and taste even better the next day. You can even use canned salmon to bump up the calcium content.	Vegetarian and salmon stuffed capsicum video

Appendix 8.15

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(See next page)

Original Paper

Improving Calcium Knowledge and Intake in Young Adults Via Social Media and Text Messages: Randomized Controlled Trial

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Abstract

Background: Calcium is an important nutrient for the attainment of peak bone mass during adolescence and young adulthood. However, these life phases are characterized as hard to reach for health promotion. Social media platforms offer a promising channel as they are relatively low cost but used ubiquitously by youth.

Objective: The aim of the CAlcium Nutrition-Dietary Opportunities (CAN-DO) study was to conduct a randomized controlled trial to test the effectiveness of Facebook alone or with text messaging as channels to deliver a theory-based program to encourage optimal calcium intake.

Methods: The intervention was a 3-arm parallel trial. Young adults aged 18 to 25 years were recruited through university and social media for a 6-week trial. Participants were randomized to 1 of the 3 arms (ie, Facebook posts, Facebook posts plus text messages, and control group that received an electronic leaflet containing information on calcium intake). The primary outcome was change in intake of milk and other calcium-rich foods, and secondary outcomes were knowledge, self-efficacy, motivation, and habit formation concerning calcium-rich foods. Changes were assessed before and after the intervention, and the differences in change between groups were compared using multivariate regression models with multiple imputations for missing data.

Results: A total of 211 participants (64/211, 30.3% males) participated (mean age 21.4 years, SD 2.1) in this study. At the end of the program, no increase in milk intake (odds ratio [OR] 1.51, 95% CI 0.61-3.75 Facebook; OR 1.77, 95% CI 0.74-4.24 Facebook plus text messages; P=.41) nor calcium-rich food was detected (P=.57). There was a significant improvement in knowledge in the Facebook plus text messages group (P<.001), but habit formation improved less than that in the other 2 groups (P=.01). Our results showed a moderate level of engagement with intervention content and positive qualitative feedback from participants.

Conclusions: The CAN-DO study delivered via Facebook (with the additional support of text messages) was found to improve knowledge and was acceptable among young adults. However, further research is needed to better understand social media engagement and how to optimize the program for participants to be sufficiently motivated to increase their intake of calcium-rich foods.

Trial Registration: Australian New Zealand Clinical Trials Registry ACTRN12620000097943; http://www.anzctr.org.au/ACTRN12620000097943.aspx

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KEYWORDS

calcium; social media; young adults; randomized controlled trial; telemedicine

Introduction

Background

As adolescents and young adults become increasingly independent, it is not uncommon for lifestyle behaviors to be adversely affected [1]. This may include decreased physical activity, increased rates of smoking and alcohol consumption, weight gain, and decreases in home-prepared meals [2-5]. Previous studies have shown that young adults are difficult to reach with traditional health promotion strategies [6,7], but it is important to support young adults through this transition to establish healthy dietary patterns for their own future health [3,8,9] and to potentially serve as role models to their children [10,11].

Among the consequences of poor-quality diets is a low intake of calcium, which remains a global concern [12] and among Australian young adults [13]. A secondary analysis from the most recent Australian National Nutrition Survey from 2011 to 2012 shows that 69% of males and 83% of females aged 19 to 25 years failed to meet the estimated average requirements for young adults [14]. An adequate intake of calcium in adolescence and young adulthood is important for the attainment of peak bone mass and prevention of osteoporosis in later life [15,16].

Our previous formative research has delved into the barriers and enablers to achieving adequate calcium intake for this population and revealed a gap in knowledge with respect to what amount of calcium-rich food constitutes a serve and the daily number of serves recommended [17]. Their level of motivation to improve calcium intake was low because a lack of knowledge meant more calcium seemed unnecessary, and financial factors influenced the opportunity to consume calcium-rich foods, wherein milk was seen as low cost, but sources such as nuts and fish were seen as high cost [17]. When asked about an appropriate medium to deliver an intervention program, the focus group participants preferred to learn from social media platforms, and Facebook was ranked as the preferred platform [17].

Young adults are ubiquitous users of social media [18]. Almost 90% of young adults (aged 18-29 years) access social media platforms at least once per day [19], so it has the potential for wide reach in an intervention. To date, the small evidence base for the effectiveness of nutrition-related interventions using a commercial social media platform, such as Facebook, is inconsistent and warrants further investigation [20-22]. Our previous meta-analysis of the effectiveness of interventions to increase calcium intake demonstrated a small effect size [23] but indicates that research into an intervention to improve calcium intake of Australian young adults is warranted.

Objective

A previous Facebook intervention for weight loss in young adults found that the use of social media combined with text messages was effective for weight loss but not Facebook alone [20]. Previous electronic health interventions conducted in young adults found a high level of acceptability and engagement with text messages and effective dietary changes [24-26]. Therefore, the aim of this study was to determine the effectiveness of an educational and motivational program to improve calcium intake in young adults and whether the addition of text messages enhanced behavior change when compared with the Facebook arm alone.

Methods

Trial Design

This was a 3-arm parallel trial with a 1:1:1 allocation ratio. The 3 groups were Facebook intervention (Facebook), Facebook intervention plus text messages (Facebook plus text), and electronic leaflet (e-leaflet) containing information on calcium intake (control). The sample size was determined using G*Power (Version 3.1.9.4, Universität Kiel), a statistical power analysis software [27]. To detect a mean difference of 125 mg calcium intake with P=.05 and 90% power, assuming a standard deviation of 259 mg, a sample size of 45 was required per arm and increased to 75 to allow for 40% dropout.

Participants

Young adults (males and females) aged 18 to 25 years were selected as this is the period where peak bone mass development is reached [28,29]. Inclusion criteria included owning a smartphone and a Facebook account. Exclusion criterion was having completed a nutrition course or currently undertaking a nutrition course on the basis of their high existing level of nutrition knowledge. In addition, any participants with a food allergy, known lactose intolerance, or currently taking calcium supplements (but not multivitamins) or eating disorders were excluded.

All materials and methods of the intervention were approved by the Human Research Ethics Committee at the University of Sydney, Australia. The ethics approval number is 2018/597. Each participant was reimbursed with an Aus $10 voucher after completing the final questionnaire. This offer did not impact the voluntary nature of consent as it was provided after the intervention finished rather than at the time of consent. The reporting of outcomes was guided by the Consolidated Standards of Reporting Trials of Electronic and Mobile HEalth Applications and onLine TeleHealth checklist [30]. As neither the primary outcome nor the secondary outcomes were clinical measurements, the study was not entered into a clinical trials registry.

Randomization and Concealment

A randomized sequence generation was used to allocate the participants. The randomization was performed by 2 independent researchers who were not study investigators.

Recruitment

Recruitment strategies included social media (posts to friends and paid advertising on Facebook), posting on University website (*volunteer for research study*), flyers (on campus noticeboards), volunteers on a research database (previous volunteers who took part in nutrition research and agreed for contact in the future), and active face-to-face recruitment. For each of the abovementioned recruitment methods, the potential participant was made aware that participation was voluntary.

Interested participants accessed the screening questionnaire for eligibility before joining the study.

CAlcium Nutrition-Dietary Opportunities Program

A theory-informed step-wise approach was used to develop the CAlcium Nutrition-Dietary Opportunities (CAN-DO) program using the Behavior Change Wheel system [31]. This framework posits that an individual requires capability (C), opportunity (O), and motivation (M) to perform a certain behavior (B) and includes a series of 9 intervention functions that can be mapped to the COM-B components [31,32].

The aim was to build relevant knowledge (capability) and influence beliefs and attitudes to generate intentions for individuals to change behaviors (reflective motivation). The details of the intervention functions and relevant behavior change techniques are presented in Table 1. In brief, the behavior change techniques included goal setting (behavior), self-monitoring of behavior, social support (unspecified), instruction on how to perform a behavior, information about health consequences, behavior substitution, habit formation, credible source, and restructuring the physical environment.

The content of the intervention was developed in 2 parts. A range of instructional videos was created to build skills in cooking calcium-rich, low-cost, and mostly plant-based meals. These were tested in focus groups for acceptability and refined based on the feedback (unpublished findings). The next step was to design text messages and Facebook posts tailored to the preferences of young adults as indicated in prior formative research [33]. The intervention content was focused on educating on calcium-containing food sources and recommended serves, tips for including more calcium, and recipe videos that provided instructions on how to incorporate calcium in main meals and snacks. Text messages were kept short (<160 characters) and designed to complement the Facebook posts. Text messages and Facebook posts also reminded participants about setting goals and tracking progress for habit formation and created social support via posts and 2-way text messaging. An infographic was created to inform participants of the recommendations and set as a cover photo on the Facebook page (Figure 1). The e-leaflet that was provided to participants in the control group is shown in Multimedia Appendix 1.

Table 1. Details of behavior change techniques with an example.

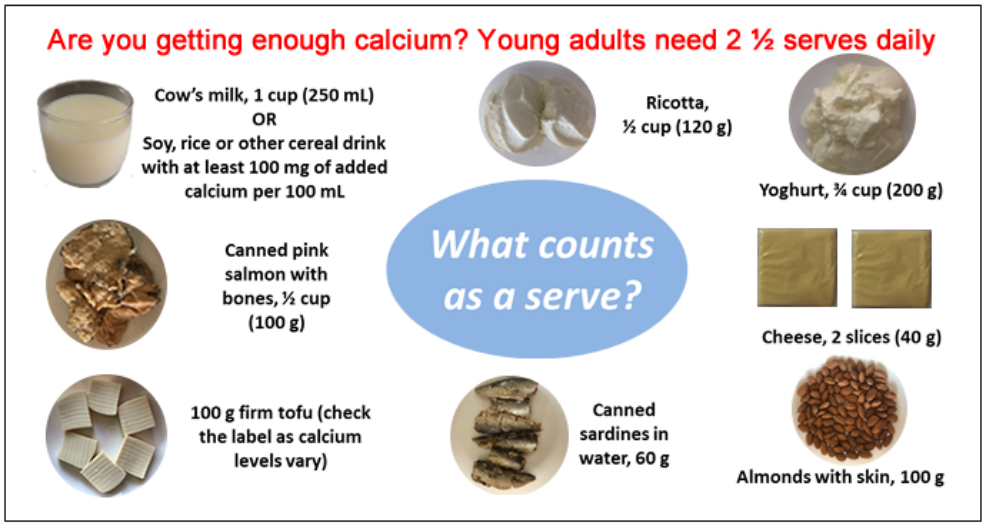
Intervention function	BCT[a,b] code	Name of BCT	An example of a Facebook post	An example of a text message
Enablement	1.1	Goal setting (behavior)	Males and females aged between 18 to 30 years should aim to consume about 1000 mg or 2.5 serves of dairy and/or alternatives per day. How much are you having? Check out this infographic which shows examples of what counts as a serve and set yourself a goal to have one more serve per day.	Hi [insert name], it's Anika from the CAN-DO[c] program. It's time to set your goals and start tracking! Have you downloaded your app and set a goal? Please reply to this message by typing YES or NO.
Enablement	2.3	Self-monitoring of behavior	Calcium intake is low in the Australian population; 44% of males and 71% of females aged 18 to 30 years don't get enough. Monitoring your progress can be useful when trying to establish new habits. You can use the app "Productive" (for iPhones) and "Loop Habit Tracker" (for Android) to track your intake.	Hi [insert name], are you still using the app to track your goals? Please reply to this message by typing YES or NO.
Enablement	3.1	Social support (unspecified)	Have you tried tofu? It is a great alternative to eggs and can be scrambled together with leftover veggies for breakfast. PS: Do you have any breakfast ideas you'd like us to share? Let us know what recipes you have tried in the comments below:)	Hi [insert name], it's Anika from the CAN-DO program. Did you check out the Facebook post yesterday? Give us a thumbs up if you like it.
Training	4.1	Instruction on how to perform a behavior	Not only is fish great for heart health, but some varieties are a good source of calcium. You can opt for canned options such as salmon or sardines that will save you time and money. Check out this salmon cannelloni recipe for a delicious way to cook with canned fish.	Hi [insert name], Have you tried any of the recipes from the cooking videos we've shared so far? Please reply to this message by typing YES or NO.
Education	5.1	Information about health consequences	It is important to get your calcium everyday as it can lower your risk of chronic diseases. Here's a photo of a veggie platter I created recently. I used the Tzatziki recipe shared on Monday as a side dip to boost the flavor. Make sure you give this a go and share your veggie platter with us :)	Hi [insert name], Did you know that calcium is important for your bone strength? To up the calcium, why not try anchovies and vegetables on your pizza.
Enablement	8.2	Behavior substitution	Is takeaway your go-to for work lunch? Try cooking larger amounts at dinner and taking the leftovers the next day for a healthier alternative. These delicious stuffed capsicums contain ricotta and parmesan and taste even better the next day. You can even use canned salmon to bump up the calcium content.	Hi [insert name], Do you get afternoon munchies? Why not swap those chips with some wholegrain crackers and cheese? Cheese is a great source of calcium and protein, and will help you beat the 3 pm slump.
Training	8.3	Habit formation	Research has shown that eating breakfast improves your cognitive function and memory. If you are not a breakfast eater, it's time to change and look after yourself! Here's an overnight chia pudding recipe for you to try.	Hi [insert name], How much calcium are you having now? Even if you've only increased a little, WELL DONE! You're on your way to healthier habits.
Persuasion	9.1	Credible source	Did you know that low fat dairy products have just as much as calcium as regular varieties? The Australian Dietary Guidelines advise that more than 50% of intake from dairy foods should be reduced-fat varieties. Check out this infographic!	Hi [insert name], Research shows that having calcium at breakfast increases your chance of meeting your requirement. Did you have your breakfast today? Reply YES or NO.
Environmental restructuring	12.1	Restructuring the physical environment	Need some meal prep inspiration? Here is a Mac and Cheese recipe you could try at home. Having pre-prepared meals in your fridge will help you avoid the temptation of take-away and keep you on track with healthy eating. TIP: to save time, you can use multiple containers to store so it is ready to grab and go for the next day!	Hi [insert name], Some canned varieties of fish with bones like salmon and sardines are a great source of calcium. Stock your pantry with canned fish for a quick calcium-rich sandwich filler.

[a]BCT: behavior change technique.

[b]BCTs were derived from Behavior Change Technique Taxonomy (version 1).

[c]CAN-DO: CAlcium Nutrition-Dietary Opportunities.

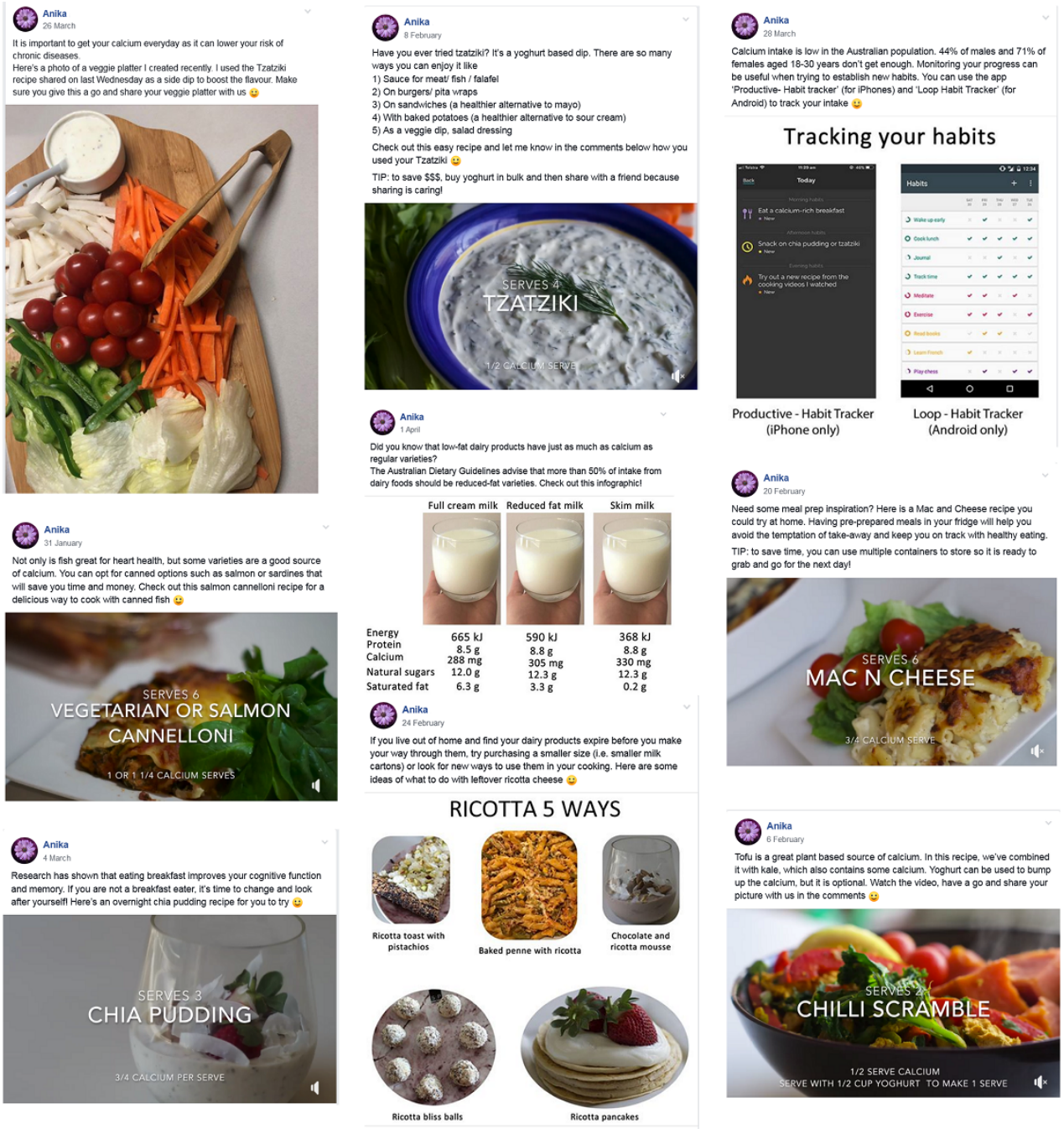
Figure 1. Infographic to inform participants of the recommendations.



Procedures

Interested participants completed a screening questionnaire hosted on Research Electronic Data Capture (REDCap) [34], where they could find out more about the study by reading the participant information statement and check their eligibility. Participants who were not eligible to participate were provided with the Australian Dietary Guidelines as a resource. Eligible participants completed the consent form and proceeded to the baseline questionnaire. After completing the baseline questionnaire, each participant was randomized to Facebook, Facebook plus text, or control group and received an email with their group allocation. Participants in the Facebook and Facebook plus text groups were invited to join a closed Facebook group, where a post was made every alternate day by the researcher (AR). The site had a pinned Facebook post used to ensure that all participants were provided with background information, which included links to educational resources and an overview of the intervention. Screenshots of the posts are shown in Figure 2. The 2 Facebook groups were kept separate to avoid potential contamination between groups. In addition, participants in Facebook plus text group were sent text messages every alternate day to the post. Participants in both intervention groups were encouraged to set goals using apps available on iPhone (Productive—Habit Tracker) and Android platforms (Loop—Habit Tracker) and self-monitor their progress. The participants in the control group were emailed once with an e-leaflet on calcium and did not receive any continued support on social media. This minimal intervention was to maintain their interest in completing the study.

Figure 2. Screenshots displaying Facebook posts that included photos, videos and the tracking apps for goal-setting and self-monitoring.



Measurement of Outcomes

Demographic information was collected from all participants, which included age, gender, educational level, postcode (for categorizing socioeconomic status), occupation, and income through a Web-based platform REDCap [34]. The postcode was used to categorize the socioeconomic status of participants using Socio-Economic Indexes For Areas (SEIFA) [35]. All outcomes were assessed at 2 time points, which were at baseline before commencing the study (T0) and at the end of intervention (T1) via a Web-based questionnaire on REDCap.

The primary outcome (calcium intake) was estimated using a validated calcium-specific food frequency questionnaire that asks about intake over the past week [36]. Milk was measured in cups, ranging from half a cup to more than 4 cups, and the other calcium-rich foods (30 foods and beverages included) were measured by weekly frequency of intake only. The secondary outcomes measured the impact of the intervention on determinants of calcium intake, which included knowledge of calcium recommendations and serve sizes, self-efficacy, motivation for consuming calcium-rich foods, and habit formation. Knowledge was assessed by a participant's ability to identify sources of calcium (maximum of 8), a correct serve of calcium (maximum of 8), and stating the calcium requirements for their age group (maximum of 2) using a researcher-designed questionnaire as no validated questionnaire could be found. The questions are included in Multimedia Appendix 2. A 5-item Likert scale questionnaire previously validated for other dietary behaviors was adapted to measure self-efficacy for improving calcium-rich food consumption. The

maximum score possible was 25; a higher score indicated stronger self-efficacy [37]. Autonomous and controlled motivation for consumption of calcium was measured using a 4-point scale. The questions were adapted from the Self-Regulation Questionnaire [38,39], where a higher score indicated greater motivation (score out of 16). Habit formation for calcium intake was measured using the validated 4-item 7-point scale Self-Report Behavioral Automaticity Index [40]. A greater score indicated a higher automaticity to perform a certain behavior.

Engagement and Process Evaluation

Engagement with the platform was measured quantitatively and qualitatively as research indicates the need to do both [41]. Quantitative measures were obtained from recording Facebook analytics. After all participants had completed the intervention, the number of participants who had seen, liked, and commented on the Facebook posts was recorded. For the Facebook plus text group, the number of replies to text messages was counted for each participant, and the content was analyzed using qualitative methods (see Qualitative Analyses below).

Feedback regarding the acceptability of the program was collected via open-response questions regarding ease of use, usefulness of program, likelihood of recommendation to others, and overall enjoyment using Likert scales (5 being highest). The other optional questions were related to intervention experience and uptake of content as well as frequency and reason for engagement. The last question provided participants with an opportunity for free text comments.

Statistical Analysis

To account for all participants, an intention-to-treat analysis with multiple imputations for missing values was used. This meant that all participants who were randomized at the start of the trial were retained for analyses. Owing to the large amount of missing data, 10 imputed datasets were created based on gender, SEIFA (socioeconomic index), cooking frequency per week, and baseline intake of primary (milk and calcium intake) and secondary (knowledge, self-efficacy, motivation, and habit) outcomes using Stata version 13.1 (StataCorp LP).

The primary outcome of change in milk intake, which was categorical in number of cups, was compared between 3 groups using a logistic regression model adjusted for gender, SEIFA, cooking frequency, baseline calcium (nonmilk), baseline knowledge, baseline self-efficacy, baseline motivation, and baseline habit. The quantitative values for change in calcium intake from other dietary sources were compared using linear regression as were the variables for the secondary outcomes of knowledge score, self-efficacy for change score, and motivation and habit score, adjusted for gender, SEIFA, cooking frequency, baseline calcium intake, baseline knowledge, self-efficacy, motivation, and habit. An analysis using completers-only data was conducted and is available in the Multimedia Appendices 3-5. The distribution of missing outcome data at both time points was investigated using counts and percentages across all sociodemographic variables. Furthermore, separate general estimating equation (GEE) models for binary data were used to investigate any relationships between sociodemographic variables and missingness in each outcome, adjusted for other sociodemographic variables. An independent samples *t* test was used to assess differences in number of views, likes, and comments for Facebook posts between the 2 groups receiving the intervention (SPSS for Windows 22.0 software IBM Corp, released 2013). A *P* value of less than .05 was considered statistically significant for all tests.

Qualitative Analyses

The feedback from the final questionnaire was transcribed and analyzed using an inductive approach where common themes were grouped together. The NVivo 12 Plus (2018, version 12.2.0; QSR International Pty Ltd) software was used for thematic analyses.

Results

Participant Characteristics

A total of 270 participants attempted the screener questionnaire. Of 270 participants, 59 were ineligible for the study or failed to continue to the baseline questionnaire. A total of 211 young adults were randomized into 3 groups. The flow of participants through the trial is shown in Figure 3. The characteristics and demographics of participants at baseline are presented in Table 2. The mean age was 21.4 years (SD 2.1), and the sample comprised 30.3% (64/211) males.

The majority of participants (139/211, 65.9%) were enrolled in tertiary education. Nearly one-third (65/211, 30.8%) of the participants were in health care for their field of work or study. Almost two-thirds (134/211, 63.5%) of the participants were earning less than Aus $500 per week. Nearly half (94/211, 44.5%) of the sample reported themselves as being the main purchaser of household groceries. The most commonly reported cooking frequency was less than twice weekly for 37.4% (79/211) of the young adults.

Figure 3. Participant flow diagram in the CAlcium Nutrition-Dietary Opportunities study.

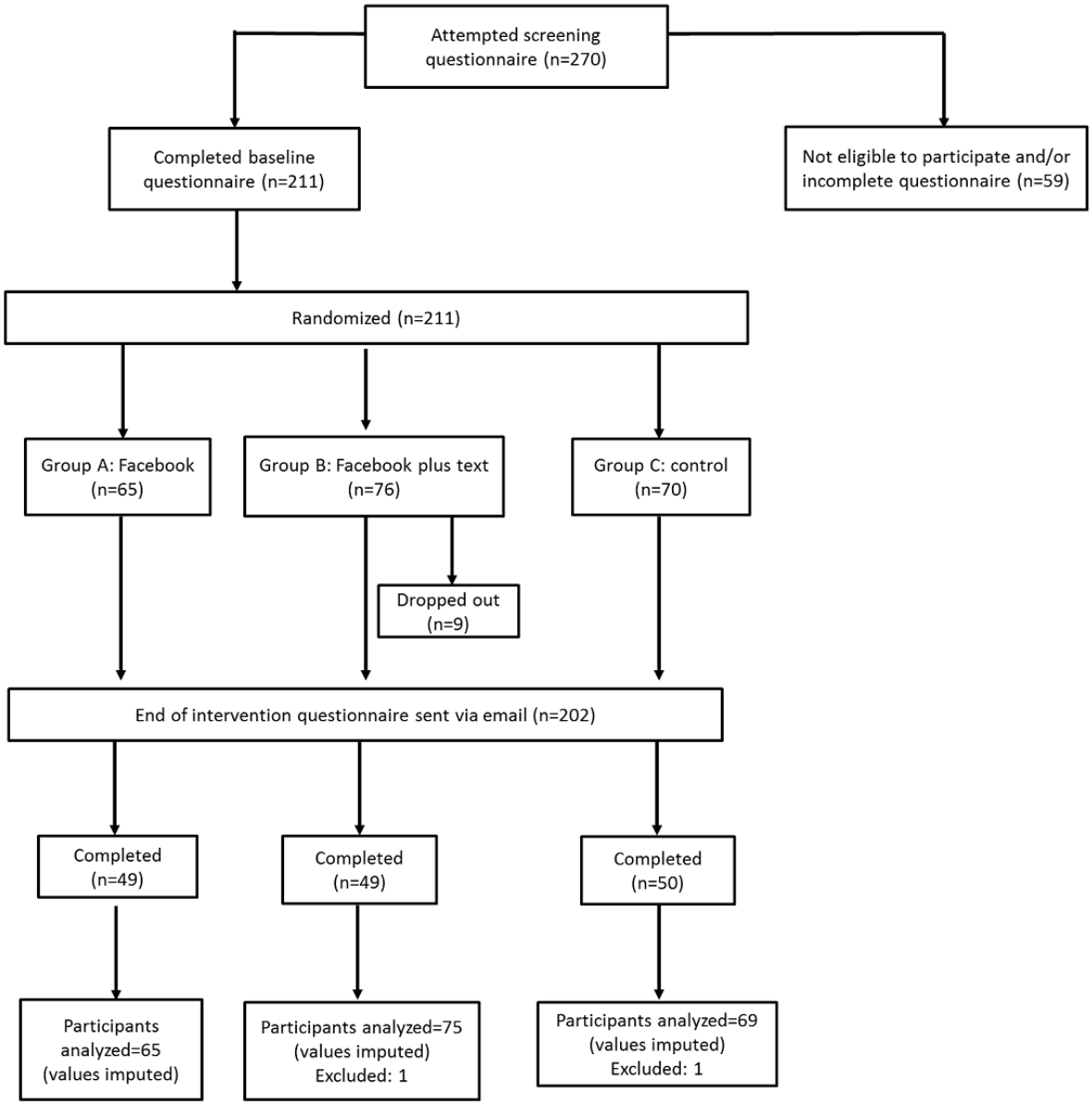


Table 2. Demographics of participants from the CAlcium Nutrition-Dietary Opportunities study.

Baseline characteristics	Facebook (n=65)	Facebook plus text (n=76)	Control (n=70)
Age (years), mean (SD)	21.3 (2.2)	21.6 (2.0)	21.4 (2.1)
Gender (n)			
Male	22	24	18
Female	43	52	52
Occupation (n)			
Student	38	53	48
Full-time work	15	14	15
Part-time or casual work	10	5	6
Unemployed	2	4	1
Field of work or study (n)			
Health care	22	20	23
Management or finance	5	7	0
Other[a]	38	49	47
Highest level of education (n)			
≤Year 12	35	34	37
Certificate or diploma	14	14	13
Bachelor or postgraduate degree	16	27	20
Prefer not to say	0	1	0
Socio-Economic Indexes For Areas (n)			
Quintiles 1 and 2	20	25	27
Quintile 3	15	29	19
Quintiles 4 and 5	30	21	23
Income per week[b] (n)			
Nil or negative income	8	19	12
Aus $1-Aus $499 per week (Aus $1-Aus $25,999 per year)	28	32	35
Aus $500-Aus $999 per week (Aus $26,000-Aus $51,999 per year)	18	15	13
More than Aus $500 per week	11	10	10
Purchaser of main household groceries (n)			
Myself	36	51	7
Others (partner, parents, and housemate/s)	29	25	63
Cooking frequency per week (n)			
Less than twice a week	23	29	27
3-4 times per week	24	24	26
5 or more times per week	18	23	17
Rating of own cooking skills (0-100), mean (SD)	63.0 (22.4)	59.4 (21.6)	57.6 (22.2)

[a]Some options from the other field of study or work include education, office support and management, food service industry, information technology, and building or construction.

[b]Includes wages/salaries, government benefits, allowances, and other income, excluding tax, superannuation contributions, or any other automatic deductions.

Attrition

Overall, 9 participants formally withdrew from the study. All participants were from the same arm (Facebook plus text) and opted out by sending a text—an option not available to other participants who could only opt out passively. The dropout time ranged from day 1 to day 29. Only 2 participants provided reasons (ie, lack of interest or time). In total, 148 (148/211, 70.1%) participants completed the final questionnaire but not necessarily every question.

Outcomes

Results from 209 participants (data from 2 participants could not be imputed because of incorrect postcodes) are reported in the following sections. Results using completers-only data are included in Multimedia Appendices 3-5. The percentage of data that were missing was approximately 35% for milk intake, knowledge, self-efficacy, motivation, and habit, but 75% for calcium-rich foods. This percentage was similar across all sociodemographic variables. The GEE indicated that females had lower adjusted odds ratio (OR) than males of have missing data, adjusted for all other sociodemographic variables. No other sociodemographic variables were associated with missing outcome values.

Primary Outcomes

Participants in the Facebook group were 1.51 times more likely to move to a higher milk category compared with those in the control group (Table 3). Similarly, those in the Facebook plus text group were 1.77 times more likely to move to a higher milk intake category. However, this was not significant (*P*=.41). There was no difference in the change in calcium intake from other foods between groups over the 6 weeks (*P*=.57; Table 4). The analysis on completers-only data demonstrated a significant increase in milk intake in the Facebook plus text messages group compared with the control group (OR 4.99, 95% CI 1.63-15.28).

Table 3. Change in category of the amount of milk intake from baseline to the end of the intervention for all participants (n=209, using imputed dataset); overall *P*=.41.

Groups	Baseline milk intake (%)			Participants who moved to a higher milk intake category (%)	Percentage increase (95% CI)	Odds ratio of participants moving to a higher milk intake category (95% CI)[a]	*P* value
	<125 mL	125-249 mL	>250 mL				
Facebook (n=65)	38.0	36.2	25.9	35.8	22.1-49.6	1.51 (0.61-3.75)	.37[b]
Facebook plus text (n=75)	27.7	40.0	32.3	41.2	29.0-53.4	1.77 (0.74-4.24)	.20[b]
Control (n=69)	37.1	30.3	32.2	28.1	15.8-40.4	Reference	Reference

[a]Covariates appearing in the logistic regression model have been adjusted for gender, Socio-Economic Indexes For Areas, cooking frequency, baseline calcium (except milk) intake, baseline knowledge, baseline habit, baseline motivation, and baseline self-efficacy. The logistic regression model was not adjusted for baseline milk consumption because everyone in the lower category having to stay the same or increase or everyone in the higher category having to stay the same or decrease. This resulted in a zero-cell count for these baseline categories in the respective outcome (0=same or decrease and 1=increase).

[b]*P* value is comparison with control as a reference.

Table 4. Change in calcium intake per day in mg (excluding milk) from baseline to the end of the intervention using logistic regression for all participants (n=209, using imputed dataset); *P*=.57.

Groups	Mean baseline intake (SE)	Mean change[a] (SE)
Facebook (n=65)	234.3 (25.0)	7.1 (39.1)
Facebook plus text (n=75)	271.9 (33.5)	65.5 (48.4)
Control (n=69)	226.4 (26.8)	43.0 (30.7)

[a]Covariates appearing in the linear regression model have been adjusted for gender, Socio-Economic Indexes For Areas, cooking frequency, baseline milk intake, baseline calcium intake, baseline knowledge, baseline habit, baseline motivation, and baseline self-efficacy.

Secondary Outcomes

Changes in secondary outcomes are reported in Table 5. The answers to the knowledge questions were combined together as an overall knowledge score. The change in knowledge was significant between the groups (*P*<.001). Those in the Facebook plus text intervention arm had a greater improvement in mean score compared with those in the Facebook and control groups. No significant difference between groups was observed for motivation (*P*=.79) or self-efficacy (*P*=.31). For habit formation, a significant group effect was observed (*P*=.01), with Facebook plus text group having the least increase in score. The improvement in knowledge in the Facebook plus text messages group was also found with completers-only analysis (*P*=.04). The effect on habit formation was not shown in the completers-only analysis.

Table 5. Change in secondary outcomes from baseline to the end of the intervention for all participants (n=209, using imputed dataset).

Outcome	Facebook		Facebook plus text		Control		*P* value[a]
	Mean baseline value (SE)	Mean change (95% CI)	Mean baseline value (SE)	Mean change (95% CI)	Mean baseline value (SE)	Mean change (95% CI)	
Habit formation score (out of 28)	15.7 (0.7)	3.5 (1.6 to 5.3)	16.4 (0.8)	0.5 (0.93 to 2.0)	15.3 (0.8)	3.4 (1.7 to 5.2)	.01
Overall knowledge score (out of 18)	6.7 (0.3)	1.6 (0.6 to 2.5)	6.3 (0.3)	2.9 (2.0 to 3.8)	6.6 (0.3)	0.2 (−0.7 to 1.1)	<.001
Motivation score (out of 16)	10.4 (0.4)	1.0 (0.3 to 1.7)	10.4 (0.3)	1.0 (0.3 to 1.8)	10.5 (0.3)	1.1 (0.4 to 1.9)	.79
Self-efficacy (out of 25)	19.4 (0.6)	1.2 (−0.1 to 2.4)	19.5 (0.5)	0.5 (−0.8 to 1.8)	17.8 (0.6)	1.0 (−0.4 to 2.4)	.31

[a]Covariates appearing in the linear regression model have been adjusted for gender, Socio-Economic Indexes For Areas, cooking frequency, baseline milk intake, baseline calcium intake, baseline knowledge, baseline habit, baseline motivation, and baseline self-efficacy.

Engagement

Facebook Posts and Text Messages

Table 6 shows the engagement with Facebook posts. More participants in the Facebook plus text intervention than those in the Facebook intervention viewed the posts and liked them (*P*<.001 for both). In the Facebook group, 3 participants made comments on posts, whereas 4 participants in the Facebook plus text group commented on posts.

For the Facebook plus text group, the mean number of replies from participants was 3.8 out of a maximum 21 (range 1-18). Of 75 participants, 12 made no reply texts (1 participant gave a wrong phone number, and texts could not be delivered). The highest number of replies was to the yes/no response as to whether they had set a goal on the app (n=22).

Table 6. Engagement with the program on Facebook.

Engagement recorded on Facebook per post	Facebook, mean (SD)	Facebook plus text, mean (SD)	*P* value[a]
Seen by	19.9 (3.6)	26.9 (5.0)	<.001
Likes	1.1 (1.4)	3.6 (2.4)	<.001
Comments	0.1 (0.5)	0.2 (0.9)	.41

[a]Conducted using an independent samples *t* test.

Process Evaluation

The majority of participants (n=133) completed the process evaluation questions, and Table 7 shows that there were no differences between intervention groups as to ease of use, their liking, likelihood of recommending it to others, or usefulness of the program. Participant responses in relation to message reading and interactions are included in Multimedia Appendix 6.

The thematic analysis with representative quotes is tabulated in Multimedia Appendix 7. The themes were grouped into ease of use, raised awareness, increased intake, feedback on recipes, reasons for reading/posting, and suggestions for improvement. Any comments that did not fit into these 5 groups were labeled as *general feedback*. There was a divergence of opinion on the ease of use, with some participants suggesting it was easy to follow, and others had more difficulty understanding and wanted more feedback. Successful participants shared their accomplishments in achieving their goals. The feedback on the recipes was overall positive, but some participants admitted they never prepared any of them. The majority of respondents chose not to share posts with reasons being they were uncertain they could add anything extra to the conversation or they did not feel comfortable with sharing. Some of the suggestions for improvement under general feedback included using an alternate platform that allows for active chat between members, sending text messages more frequently to check up on their progress, completing surveys weekly to track progress, and organizing meetings in person. Most participants viewed the notifications as a gentle and helpful reminder, whereas some found it intrusive.

Table 7. Process evaluation of the CAlcium Nutrition-Dietary Opportunities study on intervention experience.

Questions asked[a]	Facebook (n=45), rating (mean [SD])	Facebook plus text (n=44), rating (mean [SD])	Control (n=44), rating (mean [SD])
How easy was it to follow the program?	3.80 (0.89)	3.73 (1.25)	4.0 (0.96)
How much did you like the program?	3.54 (0.89)	3.57 (1.15)	3.82 (0.92)
How likely are you to recommend it to others?	3.41 (1.03)	3.50 (1.25)	3.80 (1.02)
How useful was the program to you?	3.35 (0.98)	3.57 (1.11)	3.57 (1.10)

[a]Participants were asked to rate on a scale of 1 to 5 (5 being highest).

Discussion

Principal Findings

This study showed that a 6-week intervention to increase calcium intakes tailored to young adults delivered using a social media platform and text messages was successful in improving knowledge about calcium-rich foods. However, this did not result in a significant increase in calcium-rich food and beverage intakes. The Facebook intervention delivered alone failed to show knowledge improvement, but engagement with the social media was significantly less than that in the intervention arm receiving text messages and might explain the disparate finding. Other reasons for the difference might be that the additions of texts appear to provide a more personalized program, and the need to reply to some messages engenders accountability and perception of monitoring by the staff delivering the intervention.

The findings of a successful outcome from the combined intervention arm concur with the earlier findings of a weight loss program delivered to overweight and obese college-aged students. Over 8 weeks, topics (1 per week) about weight loss were posted on Facebook, and the other intervention arm additionally received text messages with personalized feedback each week [20]. Although our text messages were generic, the participants' names were included, and they were written in the Generation Y tone for which young adults had previously expressed a preference [33]. The texts provided additional prompts to set goals and self-monitor their own behavior with some further education and persuasion. These 2 behavior change techniques have been demonstrated to result in behavior change [42].

Few dietary changes occur as a result of education alone, but it was indicated as a necessary antecedent to behavior change in this demographic based on our previous focus group findings. Although the Facebook plus text group improved knowledge, the overall score remained quite low, with the mean score only reaching 50% correct answers. Another barrier to improving calcium intakes seemed to stem from lack of motivation, with all groups scoring similarly at baseline (10 out of 16), with uniform small improvement at the end of the intervention. In future programs, more planning around the inclusion of other techniques to improve reflective motivation may be needed. Coercion, persuasion, and incentivization could be possible solutions [31]. Social media platforms readily offer the capacity for monitoring of an individual's behavior by others, and social comparison could be applied to intake of calcium-rich foods in this case. The vacillation might be that members are uncomfortable with sharing information with others as seen here in the replies to the process evaluation. The lack of posts made by group members is also indicative that such an approach may not work to positively influence motivation. Further research to understand what would allow participants to be relaxed with sharing dietary information in a nutrition intervention is desirable. With regard to incentivization and rewards, an earlier qualitative study with young adults for the co-design of an intervention to improve vegetable intakes reported that self-rewards were unlikely to motivate them as it required too much self-organization, so social or material rewards may be a better choice [21].

The validity of the food frequency instrument to measure changes in the primary outcome of calcium from milk and other foods in this population must also be questioned. Any self-report tool is always subject to participant bias [43]. In addition, this tool may not possess sufficient precision to detect small changes in intakes, as milk intakes are categorized in cups from half a serve of dairy to 4 or more serves of dairy. The calcium-specific food frequency questionnaire was selected rather than other tools as the burden of completion was low, but it does serve to rank individuals rather than assess absolute intake, and hence, the OR of increasing category of intake was used here.

Improvements in calcium intake were not achieved, but the retention and engagement in the social media intervention were substantial for an electronically delivered intervention [44]. Overall, 70% of the sample was retained, and more than half of the participants viewed the posts. Previous studies report large attrition and declining engagement in social media interventions for improving health behaviors [45]. A strength of the CAN-DO study was the formative research conducted to inform program design and materials [33]. The components were generally well received, and the recipe videos commended.

Among the limitations of this study was the overrepresentation of females comprising 70%, but this is not uncommon in nutrition studies even when males are equally targeted. In addition, in the case of calcium, it is females who are more likely to have inadequate intakes, so the population participating was appropriate. Some participants who did not do their own grocery shopping and cooked infrequently may have lessened the opportunity to alter their meals and snacks. The length of the program may have been too short to see the changes in knowledge translate into changes in consumption of calcium-containing foods, and intakes were only measured at 2 time points. An intervention delivered to university students that included a face-to-face session followed by text messages for 10 weeks did show increases in calcium intake [46]. In the

future, a longer intervention might be appropriate. Finally, to include the largest number of participants, multiple imputation was used. This increases the variance in the estimate and a more conservative interpretation of results than completers-only analysis.

Conclusions

The CAN-DO study was found to be feasible to deliver in our selected target population. Our qualitative results from the process evaluation mostly indicate that participants enjoyed the program. However, the quantitative result shows that 1 (change in knowledge) out of 5 outcomes improved in the Facebook plus text messages group only. The CAN-DO study has provided valuable insights into the process of disseminating a social media intervention for young adults, and a number of changes to program design are indicated to improve motivation. The lack of interaction between the members of the groups requires research to discover how to facilitate members to post and provide social support. This is important as it appears that the social interaction between the interventionist and participants via the text messages results in better outcomes.

Acknowledgments

AR, MN, and MAF contributed to the conception and design of the study. AR conducted the research, analyzed the data, and drafted the manuscript. MAF contributed to interpretation of the results and editing of the manuscript. All authors have read and approved the final version of the manuscript. AR was supported by the Australian Postgraduate Award Scholarship from the Commonwealth Government of Australia. The authors would like to thank Nematullah Hayba and Alyse Davis for randomizing the participants; Dr Leah Shepherd for her guidance on the statistical analysis plan and assistance with code writing on Stata; Dr Stephanie Partridge for providing guidance on multiple imputation, and the Sydney Informatics Hub, a Core Research Facility of the University of Sydney, for their assistance with statistical analysis (Jim Matthews and Christopher Howden) and survey design on REDCap (Olya Ryjenko). This research did not receive funding from any agencies.

Conflicts of Interest

MAF receives funding from the National Health and Medical Research Council, New South Wales (NSW) Health, Australian Research Council, and Cancer Council NSW.

Editorial Notice

This randomized study was only retrospectively registered. The editor granted an exception from ICMJE rules mandating prospective registration of randomized trials because the risk of bias appears low. However, readers are advised to carefully assess the validity of any potential explicit or implicit claims related to primary outcomes or effectiveness, as retrospective registration does not prevent authors from changing their outcome measures retrospectively.

Multimedia Appendix 1

E-leaflet provided to participants in Group C.
[PNG File , 2807 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Questionnaire used to measure change in knowledge at baseline and end of intervention.
[DOCX File , 636 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Change in the amount of milk intake from baseline to end of intervention (completers only).
[DOCX File , 15 KB-Multimedia Appendix 3]

Multimedia Appendix 4

Change in calcium intake per day in mg (excluding milk) from baseline to end of intervention (completers only).
[DOCX File , 14 KB-Multimedia Appendix 4]

Multimedia Appendix 5

Change in secondary outcomes from baseline to end of intervention (completers only).
[DOCX File , 15 KB-Multimedia Appendix 5]

Multimedia Appendix 6

Process evaluation of the CAN-DO study on frequency of reading posts, messages and interaction.

[DOCX File , 14 KB-Multimedia Appendix 6]

Multimedia Appendix 7

Quotations illustrating feedback from participants provided through text message replies and qualitative process evaluation (n=106).
[DOCX File , 18 KB-Multimedia Appendix 7]

Multimedia Appendix 8

CONSORT EHEALTH checklist (V 1.6.1).
[PDF File (Adobe PDF File), 2890 KB-Multimedia Appendix 8]

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Abbreviations

CAN-DO: CAlcium Nutrition-Dietary Opportunities
e-leaflet: electronic leaflet
GEE: general estimating equation
NSW: New South Wales
OR: odds ratio
REDCap: Research Electronic Data Capture
SEIFA: Socio-Economic Indexes For Areas

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Chapter Nine

Conclusions and future implications

9.1 Introduction to the chapter

This last chapter will discuss the key research findings, implications and recommendations for future research. This chapter provides a recap of the key learnings from each chapter (Section 9.2) and discusses the directions for future research (Section 9.3). The chapter closes with a thesis conclusion (Section 9.4).

9.2 Key research findings

Calcium is low in the diet of the Australian population, but particularly among young adults, and is a key public health issue that needs to be addressed. The first step in developing an effective intervention was to define the problem and understand the population. Chapter One identified young adults as the target audience. The characteristics of this population included being time poor, gaining of greater independence and the high use of technology, particularly smartphones. The next step was to review the existing evidence to establish the benefits of calcium consumption. The findings from Chapter Two demonstrated the critical role of calcium in the development of peak bone mass, as well as benefits for other chronic diseases.

The next key step was to understand the consumption patterns in the Australian population using the most recent National Nutrition Survey data from 2011-12. A secondary analysis was conducted in Chapter Three where the sources of calcium intake and how much is consumed and at what time of the day were examined. Our findings confirmed that the consumption levels were well below the national recommendations for adolescents and young adults. Furthermore,

the consumption of calcium-rich food was limited almost exclusively to breakfast and the top contributors of calcium intake were primarily from dairy foods. The findings from this chapter pinpointed specific opportunities for improvements that would be integrated into the intervention. It was established that our intervention should promote the consumption of a wider variety of calcium-rich foods (i.e. non-dairy sources) and promote intake throughout the day at all meal occasions (main meals and snacks).

The subsequent step that was undertaken prior to developing the intervention was a review of the existing literature on programs delivered to the young adult population to improve calcium or dairy intake. A systematic review was carried out to investigate the efficacy and external validity of previous interventions (Chapter Four). While the review found numerous interventions, most of them were paper-based and the use of digital platforms was limited at the time the interventions were performed. A meta-analysis was conducted which revealed that young adults responded favourably to interventions but the effect size was very small (0.35 for calcium; 0.31 for dairy). Furthermore, the use of technology was limited to online course management systems, text messaging and email. No studies employed contemporary mediums such as Facebook, Instagram or Twitter. However, it was not known at this stage whether young adults would prefer this medium. A series of focus groups were conducted to address this gap in knowledge (Chapter Five). Furthermore, it was necessary to identify the beliefs, attitudes and knowledge of calcium intake.

A thematic analysis identified the barriers young adults face to eating foods rich in calcium which included lack of knowledge, perceived lactose intolerance, large packaging of milk cartons, having other priorities and viewing it as a 'future-me' problem. The biggest barrier reported by participants was unawareness of recommendations (i.e. how much a serve is and what it looks like). It was suggested by participants that future interventions should include educational resources such as cooking videos and the behaviour should be demonstrated using

social media platforms. In particular, Facebook was voted as the most preferred platform, followed by Instagram.

The next step from here was to develop messaging for the intervention. It is well known that the framing of messages can influence behaviour. However, few studies thus far have focused on understanding the preferred tones for young adults. This was reported in Chapter Six from a cross-sectional survey. Participants were asked to select Facebook posts and text messages that were most appealing to them, as well as selecting the type and frequency of posts that would suit them. This was an important step of refining intervention materials and ensuring the selected program components were relevant to our target population. Our findings showed that Generation Y and authoritative tone with images were the most preferred.

The last stage of the formative research involved intervention design and development (Chapter Seven), as well as further testing of proposed components. The latter included the development of cooking videos which was developed with additional technical support. The process of developing the CAN-DO study was comprehensive and spanned over two and a half years from initial explorative needs assessment to the literature review, content development, program design, user testing and final refinements. Although it was a very lengthy and detailed process, it should be considered by interventionists focusing on behaviour change. The approach demonstrated in this thesis is labelled as a 'bottom-up' approach which is not only theory-based but includes a holistic approach to behaviour change. Chapter Seven provided a detailed theory-informed step-wise approach to develop the CAN-DO study which was based on a successful model for behaviour change (COM-B and behaviour change wheel by Michie et al.) (1). This included identifying intervention functions and behaviour change techniques that were suitable for delivery using social media.

The final stage of this thesis (Chapter Eight) was conducting a 3-arm randomised controlled trial to test the effectiveness of the program developed in the CAN-DO study. The aim was to assess if the behavioural components delivered using social media (through Facebook) produced positive outcomes and whether the use of text messaging enhanced the outcomes. The results of the RCT showed a significant improvement in knowledge but not intake of milk and calcium-rich foods. No significant difference in self-efficacy and motivation was found between the three groups.

While our RCT did not show any significant difference for primary and most secondary outcomes, this does not necessarily negate the use of electronic platforms for behaviour change. There was a large dropout for incompletion of dietary questionnaire but an increase in milk consumption was found in completers only. In future, employing more motivational strategies might improve the success. Finally, the CAN-DO study demonstrated that the program is equitable as our participants were from a range of socioeconomic status and incomes.

9.3 Implications of research findings with recommendations for future research

At the commencement of this thesis, limited information was available in this field to support the use of electronic platforms to deliver a behaviour change program to improve calcium intake among young adults. More importantly, no previous interventions had focused on calcium intake using a social media platform. To my knowledge, the work presented in this thesis is the first intervention developed to improved calcium intake for young adults using a theory-based approach. The CAN-DO study was guided by a comprehensive model of behaviour change which remains a unique strength of the current research.

While the RCT was unable to demonstrate effectiveness for increasing calcium intake, knowledge was improved, and it was found to be acceptable and feasible. It is likely that a

period of six weeks may not be sufficient to elicit a change in calcium intake or that the participants need to be more motivated to make a change. It is also possible that further or delayed improvements may be observed downstream as the skills and knowledge obtained during an intervention period are not applied immediately by participants. Additionally, longer follow-ups to determine maintenance of knowledge and behaviour change would be required. It is crucial that thorough testing is performed before any health promotion program prior to dissemination at large. Finally, efficacy must be demonstrated before it is rolled out to a larger scale as it justifies the use of government funding.

While the CAN-DO study was unable to demonstrate an improvement for the primary outcome, this does not negate the viability of platforms such as Facebook and text messaging. It must be noted that the program increased knowledge of participants which should be considered to be a small win. The qualitative aspect of the process evaluation was valuable feedback that could be applied for future interventions. The mixed methods approach to process evaluation is a strength of our trial as it is increasingly being used in complex interventions (2). This includes gathering quantitative measures on the delivered components (3) and a qualitative exploration of the interaction on the experience of participants (4). The latter can add value and aid with understanding problems and reasons for why a particular intervention may or may not work (4). Moreover, the use of qualitative research alongside or embedded within trials can offer unique insights into the fidelity of implementation, the contexts driving different facets of an intervention and how it is experienced by participants (5-7). However, this kind of research is often under-resourced and not always valued in practice and the rigor of qualitative research on process evaluations requires further advancement (8). In order to reap the benefits of this endeavour, researchers and funding bodies should place more value on articulating the impact of qualitative research and view it as essential to the trial (4).

To support young adults with the maintenance of dietary behaviours in the long term, health promotion programs should provide training to participants in creating action plans (detailed planning of the performance including context, frequency and duration and may include goal setting). Although the effectiveness of these components was not tested exclusively, qualitative feedback from participants suggests they found this to be a useful feature. Additionally, participants must be taught to set goals that are Specific, Measurable, Achievable, Relevant and Time-bound (SMART). For example, a goal could be made to consume 2.5 serves of calcium per day which is then translated into an action plan. This is where a participant could be guided to select specific behaviours such as including half a cup of milk in their morning porridge or breakfast scramble using tofu, calcium-rich recipes for lunch and dinner (e.g. spinach cannelloni, salmon cannelloni, sardine fishcakes), snacks such as chia pudding, yoghurt or veggie sticks with tzatziki.

Goal setting is known to be an effective behaviour change technique (9). A meta-analysis conducted on the effects of setting goals on behaviour change reported that goal setting was particularly effective if the goal was difficult, set publicly and was a group goal (10). Regrettably, there was a missed opportunity to track goals of participants within the data collection due to the suggested apps being outside of Facebook. Some possible occasions to capture goals set by participants could be through text messages and Facebook in the early stages of the intervention. It might also be useful to incorporate questions in the follow-up questionnaire related to goal-setting which asks the participants for the goal they had set at the beginning and if they were able to meet their goals.

Finally, further research is needed to understand how to engage young adults using online social support. As discussed earlier in Chapter Eight, the retention rate from the CAN-DO study was particularly high, with 70% completing the final survey. However, it must be noted that many participants did not complete every question in the surveys and the type of engagement

observed on the posts was largely passive. The majority of individuals who joined the Facebook groups "viewed" the posts. However, not as many "liked" the posts and even fewer commented, with only two participants sharing their own content. The feedback from the process evaluation shows that young adults were reluctant for a range of reasons. One common reason is thought be social desirability. The participants were reluctant to share as no one else was doing it and it would be considered as 'going against the crowd' type of act. Alternate approaches should be trialled on platforms that allow for anonymous uploading or hides identity of participants when commenting. While the majority of participants appreciated the recipes, it is not clear why they did not prepare it on their own. However, a few participants have mentioned their busy lifestyle in the feedback which is consistent with the responses mentioned in earlier chapters.

Although vigorous efforts were made to co-design and co-create the CAN-DO study with young adults, it is apparent that the willingness to interact on social media was minimal. A review has found Facebook to be the most utilised social networking site for health behaviour change (11) and was the preferred platform by young adults who took part in our formative research. As studies have shown that social contact and normative beliefs influence weight status (11), mediums delivering social support warrants further investigation. Future interventions with young adults should identify what works, for whom, how and when (12).

When co-designing an intervention, it is important to source a representative range of users and not just those who are keen to partake in research (13). Previous research conducted with young people found that monetary payments had a positive effect of respondent's willingness to participate, regardless the level of risk involved (14). It is generally thought that cash rewards may make the subject more willing to participate in research. For this reason, the $10 voucher provided to participants in the CAN-DO study was kept to a minimum and given as a reimbursement for their time (rather than an incentive).

The other feature that needs further investigation is tailoring as some participants benefitted from the text messaging. This was captured through their replies and the qualitative feedback in the process evaluation. However, all participants who dropped out from the trial were from the text messaging arm. This demonstrates that text messaging may be useful and serve as a reminder for some but it may come across as invasive and annoying for others. Providing personal tailoring and individual feedback would require additional personnel or advanced computer programming that was beyond the scope of this thesis. But it may be beneficial to randomise participants based on their personality characteristics and preferences. For example, the aspect of gamification does not motivate all users. Including features such as points, levels and leadership boards were found to be encouraging for extraverted people and may not be appropriate for the population at large (15). It is apparent that personality traits do play a role in people's perceived preferences on gamification and tailoring may influence their engagement, behaviour and learning (16, 17). The Five-Factor model is a descriptive model that classifies personality traits in terms of five basic dimensions: Extraversion, Agreeableness, Conscientious, Neuroticism and Openness to Experience (18). A previous study has found that personality traits can partly shape an individual's engagement in physical activity (19) and certain dietary habits (20-22). It is possible that tailoring the use and frequency of text messaging may have a similar effect. A recent review has encompassed tailoring in a number of ways such as anthropometric data, health-related behaviours (e.g. dietary intake, physical activity), goals (e.g. weight goal), theoretical determinants (e.g. confidence and willingness of subjects to change behaviour), psychological factors (e.g. social support) and participant location (23). Tailoring was thought to be promising as it was found to be have a small but beneficial effect on weight loss (23). In particular, text messaging interventions have been found to be effective in a systematic review of reviews, when addressing diabetes self-management, weight loss, physical activity, smoking cessation and medical adherence for

antiretroviral therapy (24). Although text messaging is generally seen to be have a positive effect across interventions, some participants in the CAN-DO study found it to be intrusive. This suggests that there is a no one size fits all approach and it may be necessary to tailor the feature of text messaging in a way that is unique to individual personality traits. It is also important to incorporate self-monitoring as research has demonstrated a significant positive relationship between self-monitoring and weight loss (25). It was been known that human support can enhance the effectiveness and adherence to eHealth interventions via "supportive accountability" to a coach who is seen as trustworthy, benevolent and having expertise (26). Nonetheless, current literature with older adults suggests that both automatic and in person feedback may be able to support the individual throughout the intervention (27). Future work in this area should consider delivering further tailoring of messages and feedback so the individual remains engaged in the self-monitoring process.

Electronic behaviour change interventions like the CAN-DO study have the potential for wider reach and could ultimately decrease the costs of public health programs. Some avenues to promote digital behaviour change interventions include paid-for advertising, digital distribution platforms, websites, public relations, use of organisational databases and workplace promotion (28). However, the delivery of effective interventions that equips young adults to improve their calcium intake is only part of the solution. Public Health Practitioners and researchers in this field should also consider campaigning for reforms. This may be within a broader environmental setting and may include the restructuring of the food environment. Some supermarket strategies that have been well researched include utilising techniques such as product placement, increasing percentage space allocated to healthier foods, using brochures and shelf labelling (29). As a large proportion of young adults attend tertiary education and spend long hours in this setting, university food outlets may be well suited for addressing nutrition related behaviours (30). However, a previous environmental audit at Australian

universities indicated undesirable nutritional quality as the most frequently available items were sugar sweetened beverages followed by chocolates, high energy foods, chips and confectionary (31). Some strategies that have been noted to have a positive effect in tertiary education settings included nutrition labelling, providing price incentives, improving healthy food availability and accessibility, combined with nutrition information or messages (32). Since the norm in Australian young adults is to attend tertiary education (33), there is an opportunity to implement these strategies to positively influence the dietary behaviour of young adults. While young adults have been labelled to be a highly desirable target for energy-dense, nutrient-poor food and beverage marketing, limited public health efforts and resources have been directed at this age group (34).

Governments have a pivotal role in public health and a strong policy is essential to achieve a food system that is healthy and processed in a way that is sustainable, equitable and profitable to all (35). Reformulation of food policies may improve affordability and accessibility. The current literature suggests that ancillary education, price reductions and health interventions are likely to be critical success factors for increasing the availability and purchases of healthy food while decreasing the purchases of unhealthy food (36). An example of a change in policy to support the introduction of subsidies to reduce the cost of fresh groceries may be useful for young adults who are engaging in full-time study and lower socio-economic communities. In our formative research, cost was reported as a barrier for particular foods such as cheese and nuts (37). It has been well known that cost is one of the primary barriers to healthy eating, particularly for young adults due to the unique idiosyncrasies during this period (38, 39).

Research shows that Australians are upskilling like never before, with 56% of the Australian population holding a tertiary level qualification which include a diploma, certificate or degree (33). This means that tertiary education represents an important context for public health, particularly for the improvement young people's health (40). Although tertiary education

settings have a pivotal role, this is an under-researched area and little is known on how to intervene in these settings. Other locations such as youth centres (YMCA and YWCA), shopping centres and major train stations could be explored to support the minority of young adults who do not attend tertiary education. It is likely that these individuals are from a low socioeconomic background and therefore will be at a greater risk of poor dietary quality (41). Workplaces can also be used for health promotions, particularly those that have a younger demographic and from lower socioeconomic groups. Evidence from three recent reviews shows that workplace interventions can improve work-related outcomes, such as absenteeism, work performance, workability and productivity (42-44). Such findings can be used to influence employers and policymakers who are involved in the decision-making and implementation process of health promotion programs.

While there is a large body of evidence to support investment in public health, there are significant barriers to investment. Some strategies that have been addressed in the literature include advocating for public health and health care interventions to be assessed equally using cost-effective analysis if possible; emphasising that an early intervention might lead to compression of morbidity; reframing discussions to reiterate the short-term effects of public health interventions and using the analogy of 'invest now for greater returns later' and personalising the potential benefits of public health interventions (45). Finally, innovation stands as an essential aspect of all public health strategy and public health programs should consider addressing the six key areas to increase their likelihood of success which include innovation, technical package, performance management, partnerships, communication and political commitment (46). Implementation of innovation at each step can improve program management with scaling up, disseminating and sustaining high-impact interventions. New partnerships and avenues must be continuously explored. This is particularly important for mHealth as it is a fast-paced environment and rapidly changing. As it is a relatively new field,

there is limited evidence on the long-term efficacy and warrants further investigation (47). A more comprehensive and rigorous approach should be applied when evaluating programs, as well as including long-term data from different locations and populations to assist with policy making and implementation (48).

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9.5 Conclusion to chapter and thesis

Given the importance of calcium for young adults, this body of research is significant. This thesis has confirmed the feasibility and acceptability of the CAN-DO study using a social media platform. However, further research is needed to confidently determine the efficacy prior to dissemination in a larger population. The novel strategies used in this thesis may serve as a guide and assist future program planners and interventionists. The strengths of this thesis include comprehensive formative research which used a user-centred approach and the use of a theory-based approach to design the intervention that used the "gold" standard randomised controlled trial to provide high level evidence.