A food-based approach to increase egg and protein intake in community dwelling British older adults aged over 55 years old

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Copyright Statement

Abstract

Dietary protein has an important impact on health, physical functioning, and muscle mass, and the prevalence of protein specific under-nutrition is high among older adults. Eggs are a nutrient dense, high quality source of protein. Compared to other protein rich foods, eggs are easy to cook, of low cost, long shelf life, soft texture, and they are familiar to most people. Therefore this PhD project aimed to explore the barriers and facilitators specific to egg intake in older adults, and use these in a food-based approach to increase egg and dietary protein intake in community dwelling older adults aged over 55 years old. Focus groups were used to identify reasons for eating or not eating eggs in adults aged 55 years and older. The 69 different reasons found were then used to design a structured questionnaire. The questionnaire results reveal that the questionnaire statements (based on the reasons) can significantly predict egg consumption in a population wide sample of British older adults. The reasons significantly related to egg consumption reveal several topics to focus on when designing strategies to increase egg consumption in older adults. One of the outcomes showed that older adults who eat more eggs report thinking eggs taste good and add variety to the diet. Adding flavour and more variety may encourage intakes in those who consume fewer eggs. A randomized controlled intervention study was designed to increase egg and protein intake, by providing recipes of protein-rich egg-based meals and herb/spice packets to encourage the addition of flavour and variety to the diet. The results showed that being in the intervention group was significantly related to higher egg intake at a follow up session at the end of the study, but not directly after the intervention. Protein intake was not different between the groups at either of the time points. The current research has showed that exposing older adults to recipes and herb/spice packets can change their egg consumption, and may therefore be helpful in an easy to implement and cost effective strategy to change eating behaviour in older adults.

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List of conference meetings attended

Meeting	Location	Dates	Activity
Nutrition Society Winter meeting	London	9 and 10 December 2014	Attendance
British Feeding and Drinking Group meeting	Wageningen (Nl)	9 and 10 April 2015	Attendance
BU Faculty of Science and Technology's PGR Conference	Bournemouth	20 May 2015	Oral presentation
Nutrition Society Summer meeting	Nottingham	6-9 July 2015	Poster presentation*
Nutritional Care Wessex: Perspectives on Malnutrition	Southampton	29 September 2015	Poster presentation
Food Matters Live	London	17 November 2015	Attendance
BU Graduate school PGR conference	Bournemouth	9-10 March 2016	Poster presentation
British Feeding and Drinking Group meeting	London	7-8 April 2016	Oral presentation*
BU Faculty of Science and Technology's PGR Conference	Bournemouth	18 May 2016	Poster presentation
Nutrition Society Summer meeting	Dublin	11-14 July 2016	Poster presentation*
British Feeding and Drinking Group meeting	Reading	6-7 April 2017	Oral presentation*
BU SciTech PGR conference	Bournemouth	24 May 2017	Oral presentation
Nutrition Society Summer meeting	London	10-12 July 2017	Poster presentation*

*Abstract published

Author’s Declaration

I hereby declare that the work presented in this thesis has not been and will not be, submitted in whole or in part to another University for the award of any other degree.

Signature:

1. Introduction

1.1 Context of the research

The British older population is rapidly increasing (Office-for-National-Statistics, 2012), which makes it increasingly relevant to maintain or improve health and wellbeing in later years. Protein specific under-nutrition is common among older adults, although the exact prevalence depends on which intake cut off is used to define it. Prevalence ranges from 1-24% if based on the estimated average requirement, but it can be as high as 77% when higher intake recommendations are used (Berner, Becker, Wise, & Doi, 2013; Fulgoni, 2008; Jyväkorpi et al., 2015; Tieland, Borgonjen-Van den Berg, Loon, & Groot, 2012). Dietary protein intake has an important impact on health, physical functioning, and muscle mass, and it has been suggested that the protein requirements for older adults are higher than current recommendations (Bauer et al., 2013; Deutz et al., 2014; Wolfe, Miller, & Miller, 2008).

Many other studies aiming to increase protein intake in older adults have used protein supplements and protein enriched foods (e.g. (Cuthbertson et al., 2005; Moore et al., 2014; Tieland, van de Rest, et al., 2012), but they are often disliked or not acceptable to many older adults (Gosney, 2003; Kennedy, Law, Methven, Mottram, & Gosney, 2010; van der Zanden, van Kleef, de Wijk, & van Trijp, 2014a).

Increasing intake of 'conventional' protein rich foods in older adults has been related to specific challenges. Barriers to eating protein rich foods include sensory characteristics, physical abilities involved in food preparation and food shopping, and eating capabilities, e.g. biting, chewing, or swallowing, (Appleton, 2016; Best & Appleton, 2013; Deutz et al., 2014; Volpi et al., 2013). It has also been shown that perceived convenience, value for money, and perishability are important positive predictors of intakes of protein-rich foods in older adults (Appleton, 2016). Moreover, studies have shown that intake of protein rich foods for older adults is strongly affected by familiarity with the foods, habit and past eating behaviour (Best & Appleton, 2013).

Eggs are a nutrient dense, high quality source of protein (Ruxton, Derbyshire, & Gibson, 2010; Smith & Gray, 2016). Sensory analyses with older adults have previously shown that eggs were popular for their soft texture, while different types

of meat were characterized to have more difficult to eat textures (Rousset & Jolivet, 2002). Compared to other protein-rich foods, eggs are also easy to cook, of long shelf-life and low cost (Drewnowski, 2010; Lewis & Bashin, 1988). Moreover, eggs are a familiar food to many people (Smith & Gray, 2016). With eating eggs older adults may overcome the specific barriers to eating protein rich foods. Therefore, eggs may be of help in increasing dietary protein intake in older adults.

This research project is focused on increasing egg intake in older adults with the aim to increase total protein intake. In order to design an intervention to increase egg intake in older adults, a thorough understanding of egg consumption in the target age population is key. Therefore this PhD project aimed to explore the barriers and facilitators specific to egg intake in older adults, and use these in a food-based approach to increase dietary protein intake in British older adults aged over 55 years old.

The following outline will describe how different types of studies were conducted to attain a better understanding of using eggs to increase protein intake in older adults:

- Chapter 2 gives an in depth literature review including the role of dietary protein intake in older adults, eating behaviour specific to older adults, and egg consumption in older adults.
- Chapter 3 reports the first study of this PhD project, in which focus groups and interviews were used to identify reasons for eating or not eating eggs in adults aged 55 years and older.
- Chapter 4 reports the second study of this PhD project. In this study the reasons for eating or not eating eggs were used to design a structured questionnaire. The questionnaire was sent out to a large National sample to explore which reasons can be related to high egg intake in British older adults.
- Chapter 5 describes the third study of this PhD project, a randomized controlled trial in which recipes and herb/spice packets were used to provide older adults with new ideas to add more flavour and variety to the diet. The intervention of providing recipes of protein rich egg based meals was designed to encourage older adults to consume more eggs and protein.
- Chapter 6 includes further exploratory analyses of the results from the randomized controlled trial, to see if the participant characteristics or reasons for eating or not eating eggs are related to change in egg intake, and explore feedback from participants in the intervention group.

- Lastly, chapter 7 will discuss the key research findings, challenges in the current research, and implications for future research.

1.2 Aim and objectives

This section will review the overall aim and objectives of this PhD project. The aim is explained in section 1.2.1, the three objectives are described in sections 1.2.2-1.2.4.

This thesis was set out to increase egg intake and protein intake in older adults. There are specific challenges to changing eating behaviour in older adults in general, and to eating eggs specifically. When reviewing the literature related to the research topic (described in chapter 2), several topics emerged that may currently be under-supported in the existing literature. These specific issues have inspired the overall aim of this PhD project.

- The aim of this project is to explore the barriers and facilitators specific to egg intake in older adults, and use these in a food-based approach to increase egg and dietary protein intake in community dwelling British older adults aged over 55 years old.

- The objectives of this project are:
    - Identify the reasons for eating or not eating eggs in older adults.
    - Find the reasons for eating or not eating eggs which are associated with habitual high egg consumption in older adults.
    - Find whether an intervention study, designed to specifically focus on the reasons found most strongly predicting egg intake, can increase egg consumption in older adults.

1.2.1 Aim: To explore the barriers and facilitators specific to egg intake in older adults, and use these in a food-based approach to increase egg and dietary protein intake in community dwelling British older adults aged over 55 years old.

Firstly, this PhD project was aimed to take a food based approach. Most studies aiming to increase protein intake in older adults use protein supplements or enriched foods (e.g. (Cuthbertson et al., 2005; Moore et al., 2014; Tieland, van de

Rest, et al., 2012), but eating behaviour in older adults is known to be affected by habits and familiarity, and food neophobia may increase with age (Meiselman, King, & Gillette, 2010). Moreover, for many older adults ONS and protein enriched foods are often disliked or not acceptable (Gosney, 2003; Kennedy et al., 2010; van der Zanden et al., 2014a; van der Zanden, van Kleef, de Wijk, & van Trijp, 2015). Using a food based approach may be more successful in increasing protein intake, because the foods are more likely to be familiar and changes in eating habits will be smaller than when introducing a new/unfamiliar food product. Therefore conventional foods are used in this study.

For this PhD project increasing egg intake is suggested as a strategy to increase protein intake. Compared to other protein rich food, eggs may be particularly appropriate for older adults with potential difficulties in their physical abilities and eating abilities. Eggs are easy and quick to cook, and they are of soft texture which makes them easy to chew. They are a high quality source of protein, and contain other nutrients beneficial to older adults (Ruxton et al., 2010).

This PhD project aims to use a bottom up approach by finding the specific reasons for eating or not eating eggs in this specific target age group. A good understanding of the barriers and facilitators specific to egg intake in older adults could help to increase dietary protein intake in older adults. The literature review in chapter 2 will show determinants for general food choice in older adults (Locher et al., 2009), and determinants for eating eggs in younger adults (Fearne & Lavelle, 1996b), but it is unclear how they would relate to egg intake, or older adults respectively. Qualitative methodology will be used to identify the reasons for eating and not eating eggs in older adults. These reasons will then be used in a questionnaire study to find how they relate to habitual egg consumption in a large population wide quantitative research study. The outcomes of the questionnaire study will then be used to design an intervention study.

Lastly, this PhD project includes adults aged 55 and over. Older adults are often defined as being 65 years old and older (WHO, 2002), and many studies aiming to increase protein intake in older adults include adults over 65 years old (Beasley, Shikany, & Thomson, 2013; Milne, Avenell, & Potter, 2006; Morton et al., 2017). For this project the age cut off of 55 years old and over was chosen for different reasons. The literature review in Chapter 2 shows that, although people may only notice it years later, the rates of muscle strength loss seem to start increasing

around the age of 50 years, and accelerating faster from 60 and 70 years (Keller & Engelhardt, 2013). Moreover, if the willingness to change eating behaviour may decrease with age (Meiselman et al., 2010), it may be easier for a younger target age group. With a goal to include adults who would benefit from prevention as well as treatment this project is focused on a wider age range from 55 years and older. Within this wide age range it is assumed that some individuals may have different lifestyles, health statuses, and physical abilities. The older population, and their eating behaviour, is thought to be strongly heterogeneous (den Uijl, Jager, de Graaf, Waddell, & Kremer, 2014; van der Zanden, van Kleef, de Wijk, & van Trijp, 2014b). The intention of this research project was not to look at age specific changes, but look at eating behaviour in the group as a whole.

1.2.2 Objective 1: Identify the reasons for eating or not eating eggs in older adults.

A good understanding of the barriers and facilitators specific to egg intake in older adults could help to design a specific strategy to increase egg consumption. Other studies have reported on eating behaviour in older adults, and determinants for eating eggs in younger adults, but to the author's knowledge there are no qualitative studies identifying the reasons specific to eating or not eating eggs in older adults. Determinants reported in the existing literature could only be used making assumptions on whether the determinants of general food choice will also apply to eggs, and/or whether the determinants for egg consumption in younger adults would also apply to older adults. Instead, this PhD project is designed to use a more inductive approach to understand why people in this target age group eat or do not eat eggs. Food intake is not just about the physical need for energy, but can have a complex role in a person's life (Chamberlain, 2004; Swift & Tischler, 2010). Qualitative research is especially suited for exploring why people behave/eat in a certain way (Swift & Tischler, 2010). Focus groups and interviews will be used to identify the specific reasons for eating or not eating eggs in British older adults. At this stage of the project there is no distinction in relative importance between the reasons and the potential barriers and facilitators to egg consumption will not yet be related to actual eating eggs. The focus is solely to identify as many reasons as possible until data saturation was reached.

1.2.3 Objective 2: Find the reasons for eating or not eating eggs which are associated with habitual high egg consumption in older adults.

The reasons for eating or not eating eggs which have been identified using qualitative research methods are then used to design a structured questionnaire. For this cross-sectional study, the questionnaire will be sent out to a large National sample to see whether the reasons for eating or not eating eggs are related to habitual egg consumption across the British elderly population. The responses will give insight into the relative importance of the reasons for eating or not eating eggs in predicting the habitual consumption of eggs in older adults. The results will show whether the reasons for eating or not eating eggs are positively or negatively related to egg intake, and therefore whether these determinants are barriers or facilitators to egg consumption in British older adults.

1.2.4 Objective 3: Find whether an intervention study, designed to specifically focus on the reasons found most strongly predicting egg intake, can increase egg consumption in older adults.

For the third objective of this PhD project, the outcomes of the questionnaire study are used. After identifying the specific reasons for eating or not eating eggs in older adults in a qualitative study, and finding how the reasons relate to habitual egg consumption based on population wide data, the outcomes of the questionnaire study will be used to design an intervention study. One of the reasons that is significantly related to higher egg intake in the National sample will be chosen as the main focus to design a strategy to increase egg consumption in older adults. If a specific reason is significantly related to egg consumption, a certain direction of agreement with the statement is related to higher egg intake and the opposite direction is related to lower egg intake. Therefore, focussing on this reason may encourage low egg consumers to increase egg intake, and with this total protein intake.

2. Increasing protein and egg intake in older adults: a literature review

The following chapter gives an in-depth review of the literature about protein specific under-nutrition in the elderly population and the importance of dietary protein (section 2.1). It also reviews specific determinants of eating behaviour in older adults (section 2.2). Lastly, the chapter includes literature about eggs, and factors related to egg consumption in older adults (section 2.3), and finish with a summary (section 2.4).

2.1 Dietary protein intake in older adults

2.1.1 Protein specific under-nutrition in older adults

Food intake for adults decreases approximately 25% between the ages of 40 years old to 70 years old (Nieuwenhuizen, Weenen, Rigby, & Hetherington, 2010), and older adults are known to eat less protein than younger adults (Bates et al., 2014; Fulgoni, 2008; Volpi et al., 2013). Protein specific under-nutrition can be defined based on protein intake under the protein recommendation or estimated requirement. Estimating prevalence depends on which recommendation is used, and which population. Prevalence of protein specific under-nutrition ranges from 1-24% if based on the Estimated Average Requirement (EAR) of 0.66g of protein per kg of body weight (Berner et al., 2013; Fulgoni, 2008; Tieland, Borgonjen-Van den Berg, et al., 2012), but it can be as high as 77% when higher recommendations are used (Jyväkorpi et al., 2015).

Dietary protein can have an important impact on health outcomes that are likely to affect the elderly population (Bauer et al., 2013; Deutz et al., 2014; Wolfe et al., 2008). It has been suggested that protein intake is associated with functional abilities (Imai et al., 2014), reduced risk of incident frailty (Beasley et al., 2010; Kobayashi, Asakura, Suga, & Sasaki, 2013), falls (Zoltick et al., 2011), and fractures (Sahni et al., 2010) decreased bone mineral density and bone mass (Beasley et al., 2014; Dawson-Hughes, 2003; de Souza Genaro & Martini, 2010; Rapuri, Gallagher, & Haynatzka, 2003), improved glucose control in type 2 diabetes (Nuttall & Gannon,

2006), lower blood pressure and lower risk of coronary heart disease (Appel et al., 2005; Hu, Stampfer, Manson, et al., 1999; Stamler et al., 1996). Moreover it has been shown that increased protein intake is positively related to the prevention (Stratton et al., 2005), and recovery (Hughes et al., 2006; Schurch et al., 1998) of different types of injuries. There are indications that increasing daily protein intake may positively influence muscle mass and function in the elderly (Beasley et al., 2010; Beasley, Shikany, et al., 2013; Beasley, Wertheim, et al., 2013; Gregorio et al., 2014; Houston et al., 2008; Komar, Schwingshackl, & Hoffmann, 2015; Malafarina, Uriz-Otano, Iniesta, & Gil-Guerrero, 2013).

Sarcopenia is defined as the age-related loss of skeletal muscle mass and strength. Recently, many studies focus on the loss of muscle mass and strength because it has been associated with problems in functional capability and mobility, falls and length of hospital stay, osteoporosis, poor quality of life and mortality (Cruz-Jentoft et al., 2010; Cruz-Jentoft et al., 2014; Deer & Volpi, 2015; Di Monaco et al., 2015; Gariballa & Alessa, 2013; Janssen, Heymsfield, & Ross, 2002; Landi et al., 2013; Landi et al., 2012; Lauretani et al., 2003; McLean et al., 2014; Sayer et al., 2006; Scott et al., 2014; Tanimoto et al., 2012). The causes of sarcopenia are multi-factorial; but the risk factors include inadequate dietary protein intake and anabolic resistance to protein intake (Cruz-Jentoft et al., 2010; Millward, 2012). Volpi and colleagues were the first to show that available amino acids affect muscle protein synthesis (MPS) rates differently between age groups, with a lower anabolic response in older than in younger adults (Volpi, Sheffield-Moore, Rasmussen, & Wolfe, 2001). This age related blunted response is referred to as anabolic resistance (Breen & Phillips, 2011). Anabolic resistance to the ingestion of protein is thought to play an important role in the onset and progression of sarcopenia (Churchward-Venne, Breen, & Phillips, 2014). Not eating enough protein to meet individual requirements could lead to negative protein balance and potential loss of muscle mass and strength (Deer & Volpi, 2015). Fortunately, the above mentioned internal processes can be influenced by several lifestyle factors like physical activity and protein intake (Deutz et al., 2014). Depending on physical abilities and health status, the ability and/or capacity to exercise can be limited in some older adults and increasing exercise may not always be feasible (Deer & Volpi, 2015; Paddon-Jones & Leidy, 2014). In this case increasing protein intake may be one of the remaining options to preserve muscle mass and function. Therefore, this project is only focussed on protein intake in older adults.

With the older population increasing rapidly, it has become increasingly relevant to maintain or improve health and wellbeing in later years (Office-for-National-Statistics, 2012). Higher muscle strength and muscle mass are associated with higher quality of life and improved physical abilities in daily activities (Cruz-Jentoft et al., 2010). Increasing dietary protein intake can have a great impact on the health and wellbeing of older adults.

2.1.2 Target age range

It has been suggested skeletal muscle mass generally starts to decrease from the age of 30 years old (Rosenberg, 1997; Sehl & Yates, 2001). From being 50 years old and onward, aging is associated with "pronounced changes" (Keller & Engelhardt, 2013), loss of muscle mass and strength, and sarcopenia (Cuthbertson et al., 2005). Average loss of muscle mass is suggested to be between 0.5–2% per year from 50 years old (Cuthbertson et al., 2005; Keller & Engelhardt, 2013). Average loss in muscle strength can be 1.5% per year between 50-60 (von Haehling, Morley, & Anker, 2010) or 50-70 years old (Zatsiorsky & Kraemer, 2006), after which the rates double to 3% loss of strength per year (from 60 years old, or 70 years old respectively). The changes in muscle mass and strength may be so gradual, and go alongside small adaptations in lifestyle, that physical function might only be affected around the age of 60 (Paddon-Jones & Leidy, 2014; Wolfe, 2012). Paddon-Jones and colleagues suggest that while "middle age adults" (40-65 years old) may respond to muscle metabolism studies like the younger adults, periods of physiological stress (inactivity, injury, malnutrition) can promote anabolic resistance and increase muscle loss like in the older adults (English & Paddon-Jones, 2010; Paddon-Jones & Leidy, 2014). With the intention to focus on the importance of maintaining muscle mass and strength, the research studies as part of this PhD project have included participants from 55 years old.

2.1.3 Current protein intake and recommendations

The UK Reference Nutrient Intake (RNI) for daily protein intake is 0.75 g of protein per kg of body weight for all adults, or 53.3g for 50+ aged males, and 46.5g for 50+ aged females (Department-of-Health, 1991). The World Health Organisation (WHO) Recommended Dietary Allowance (RDA) for all adults is 0.8 g of protein/kg body weight/day, and indicates the level of intake considered likely to be sufficient to meet the requirements of 97.5% of healthy adults. The Estimated Average

Requirement (EAR) is 0.66 g/kg/day, and indicates the level of intake considered likely to be sufficient to meet the requirements of 50% of healthy adults.(Joint, 2007). It has, however, been suggested that the protein requirements may be higher for older adults. There are indications that RDA intake of protein is not adequate to maintain skeletal muscle in elderly (Campbell, Trappe, Wolfe, & Evans, 2001). Different research groups have recommended that for healthy older adults daily intake should be up to 1.0-1.2 g of protein/kg body weight (Bauer et al., 2013; Deutz et al., 2014). Houston et al (2008) showed that intake of 1.2 g/kg/day significantly lowered muscle mass loss with 40% compared to a protein intake of 0.8 g/kg/day. The current requirement levels for all adults are based on avoidance of negative nitrogen balance studies mainly conducted in healthy young men (Rand, Pellett, & Young, 2003). This technique also has several other limitations that make it likely to underestimate protein requirements (Courtney-Martin, Ball, Pencharz, & Elango, 2016; Gaffney-Stomberg, Insogna, Rodriguez, & Kerstetter, 2009). Using a new technique Indicator Amino Acid Oxidation (IAAO), protein requirements for elderly men and women were estimated to be 1.2 g/kg/day as RDA and 0.9 g/kg/day for EAR (Courtney-Martin et al., 2016; Rafii et al., 2016; Rafii et al., 2015; Tang et al., 2014). This is in line with the suggested higher recommendation of 1.0-1.2 g/kg/day (Bauer et al., 2013; Deutz et al., 2014).

Because of the different recommendations it is difficult to define protein specific undernutrition, and its prevalence. Data from the National Diet and Nutrition Survey (NDNS) show that UK elderly (over 65 years old) have a mean daily protein intake of 69.8g compared to 75.2g for 19-64 year old adults (Bates et al., 2014). Although they still meet the UK RNI, older adults are eating less than younger adults while they may need more protein per day. (Beasley et al., 2014; Beasley et al., 2010; Dawson-Hughes, 2003; de Souza Genaro & Martini, 2010; Hughes et al., 2006; Imai et al., 2014; Kobayashi et al., 2013; Rapuri et al., 2003; Schurch et al., 1998; Stratton et al., 2005; Zoltick et al., 2011). Please see table 2.1 for an overview of all dietary reference values.

Intervention studies on the effect of increasing dietary protein intake on muscle mass and physical function sometimes show conflicting results (Beasley, Shikany, et al., 2013; Milne et al., 2006; Murphy, Oikawa, & Phillips, 2016), which could be explained by the growing evidence suggesting that on top of total amount of protein ingested, the distribution of protein intake over the day affects skeletal muscle protein synthesis (Murphy et al., 2016; Paddon-Jones & Rasmussen, 2009).

Table 2.1 Dietary reference values from different sources and research groups.

Dietary reference values	Definition	Values and target group	Group	Reference
Average Requirement (AR)	Level of intake considered likely to be sufficient to meet the requirements of 50% of healthy adults.	0.66 g/kg/day for all adults	European Food Safety Authority (EFSA)	EFSA Panel on Dietetic Products, Nutrition and Allergies (2012)
Estimated Average Requirement (EAR)	Level of intake considered likely to be sufficient to meet the requirements of 50% of healthy adults.	0.66 g/kg/day for all adults	World Health Organisation (WHO)	Joint, W. (2007)
Estimated Average Requirement (EAR)*	Level of intake considered likely to be sufficient to meet the requirements of 50% of healthy adults.	0.9 g/kg/day for all adults	Researchers from the University of Toronto, the University of Alberta, and the University of British Columbia.	Courtney-Martin, G., Ball, R. O., Pencharz, P. B., & Elango, R. (2016)
Reference Nutrient Intake (RNI)	Level of intake considered likely to be sufficient to meet the requirements of 97.5% of healthy adults.	0.75 g/kg/day for all adults	UK Department of Health	Department of Health (1991)
Population Reference Intake (PRI)	Level of intake considered likely to be sufficient to meet the requirements of 97.5% of healthy adults.	0.83 g/kg/day for all adults	European Food Safety Authority (EFSA)	EFSA Panel on Dietetic Products, Nutrition and Allergies (2012)
Recommended Dietary Allowance (RDA)	Level of intake considered likely to be sufficient to meet the requirements of 97.5% of healthy adults.	0.83 g/kg/day for all adults	World Health Organisation (WHO)	Joint, W. (2007)
Recommended Dietary Allowance (RDA) *	Level of intake considered likely to be sufficient to meet the requirements of 97.5% of healthy adults.	1.2 g/kg/day for all adults	Researchers from the University of Toronto, the University of Alberta, and the University of British Columbia.	Courtney-Martin, G., Ball, R. O., Pencharz, P. B., & Elango, R. (2016)
Recommended Dietary Allowance (RDA)	Level of intake considered likely to be sufficient to meet the requirements of 97.5% of healthy adults.	1.0-1.2 g/kg/day for older adults (>65y)	PROT-AGE - Study Group on meeting protein needs of older people	Bauer, J., Biolo, G., Cederholm, T., Cesari, M., Cruz-Jentoft, A. J., Morley, J. E., . . . Teta, D. (2013)
Reference Nutrient Intake (RNI)	Level of intake considered likely to be sufficient to meet the requirements of 97.5% of healthy adults.	53.3g/day for males >50y 46.5g/day for females >50y	UK Department of Health	Department of Health (1991)

*Based on Indicator Amino Acid Oxidation (IAAO)

2.1.4 Distribution and dose of dietary protein intake

It has been suggested that 25-30g of high quality protein is needed to reach a threshold for optimal stimulation of MPS and overcome anabolic resistance (Paddon-Jones & Rasmussen, 2009). Analyses of the American NHANES data also show that the frequency of consuming 30g of protein per meal was related to a higher muscle mass and strength (Loenneke, Loprinzi, Murphy, & Phillips, 2016; Murphy et al., 2016). Adults 50-85 years old in the NHANES data set showed a significant difference in muscle strength and lean body mass between people who ate at least 30g of protein for one meal compared to none, and between people who ate 30g of protein for two meals compared to one meal per day (Loenneke et al., 2016), which suggests that every extra occasion per day of reaching the optimal protein threshold could have significant health benefits. Other studies showed that MPS rates in non-frail older adults were significantly greater after 20g or 40g of protein compared to 0g of protein, with no significant difference between MPS rates after 20 g and 40g (Yang et al., 2012). Moore et al. showed that healthy older adults have the capacity to reach similar maximal MPS rates as younger adults, but they needed a higher dose of protein per meal to reach it (Moore et al., 2014). To stimulate maximal MPS rates in the elderly muscles in a resting condition, 0.40g of protein per kg of body weight per meal was needed compared to 0.24g/kg/meal in younger adults (Moore et al., 2014). Assuming a meal pattern of three meals per day, three times a protein intake of 0.4 g/kg/meal is in line with the suggested recommendation for older adults of 1.2g/kg/day (Bauer et al., 2013; Deutz et al., 2014). Symons and colleagues showed no difference in anabolic reaction between young and older adults after consuming a lean beef patty (containing 30g of protein) (Symons et al., 2007), and that for both young and older adults there is no difference in MPS after eating either 30 or 90g of protein at one meal (Symons, Sheffield-Moore, Wolfe, & Paddon-Jones, 2009). This seems to indicate that amounts of protein higher than the optimal range do not provide a more beneficial effect.

Studies show that protein intake distribution over the day is generally very skewed to the main meal (a hot meal at either lunch or dinner time) and low for breakfast (Berner et al., 2013; Mamerow et al., 2014; Tieland, Borgonjen-Van den Berg, et al., 2012; Valenzuela et al., 2013; Volpi et al., 2013). An experimental even distribution of protein intake over breakfast (30g), lunch (30g) and dinner (30g) resulted in a 25% higher MPS rate in middle aged adults than when measured following a diet with equal amounts of total energy and protein, but protein intake “skewed” with a

higher intake at dinner (Mamerow et al., 2014). In a cross sectional study dietary patterns of frail, pre-frail and non-frail elderly people were compared. Although total daily protein intake was similar for all groups, the non-frail group had a more evenly distributed protein intake throughout the day, while the pre-frail and frail groups showed a protein intake distribution that was skewed (Bollwein et al., 2013). Farsijani and colleagues showed that in a longitudinal cohort study an even distribution of protein intake was associated with higher muscle strength, independent of total protein intake (Farsijani et al., 2017), and higher lean body mass (Farsijani et al., 2016). However, other studies showed that older adults spreading out protein intake over the day had significantly lower increases in lean mass than the elderly on a skewed protein diet (with most of the daily protein at lunch) (Arnal et al., 1999; Bouillanne et al., 2013). The conflicting results on the effect of protein distribution could be explained by the amount of protein consumed at each meal. If the dose of protein per meal in the spread diet are below the threshold (in this case they were 12-21g of protein), the skewed diet could be more beneficial because one meal was high enough in protein to overcome anabolic resistance compared to none of the meals in the spread diet (Bouillanne et al., 2013) .

2.1.5 Quality of different protein sources

The recommended amounts of protein mentioned above assume a high quality, rapidly digested animal based protein (Moore et al., 2014). In addition to the amount of protein consumed per day and per meal, the quality of the protein is important. The quality of the protein source is related to the essential amino acid (EAA) composition and digestibility (Consultation, 2011), these determinants also influence the capacity of the protein to stimulate MPS (Churchward-Venne et al., 2014; Volpi, Kobayashi, Sheffield-Moore, Mittendorfer, & Wolfe, 2003). Elderly women showed a higher net protein synthesis after the high animal protein diet than after a high plant protein diet (Pannemans, Wagenmakers, Westerterp, Schaafsma, & Halliday, 1998). Differences in digestion and absorption of plant based proteins compared to animal based proteins result in a lower amount of amino acids available for MPS (Consultation, 2011; Fouillet, Mariotti, Gaudichon, Bos, & Tomé, 2002). Moreover, animal based proteins, like meat, fish, eggs and dairy products, contain all EAA and are considered high quality protein sources, while plant-based protein sources can lack one or more of the EAA (van Vliet, Burd, & van Loon, 2015). Supplementing EAAs has been shown to affect MPS, lean body mass, and muscle strength and

function (Børsheim et al., 2008; Dillon et al., 2009; Ferrando et al., 2010). Moreover, some studies indicate associations between total protein and animal protein with lean body mass and strength, but not with plant protein (Isanejad et al., 2015; Sahni, Mangano, Hannan, Kiel, & McLean, 2015).

Some studies do not show differences in MPS rates after balanced or skewed meal pattern, which could potentially be explained by the quality of proteins and mixed meals instead of supplements (Kim et al., 2015; Murphy et al., 2015). Notably, a large proportion of dietary protein intake in British older adults is from plant sources (Bates et al., 2014). For a lower quality source of protein with fewer EAA, the amount of protein needed per meal would likely be higher (Murphy et al., 2016). Increasing intake of total protein to even higher levels than for high quality protein might be difficult because of the satiating effects the protein may have.

2.1.6 Protein and satiety

One specific characteristic of protein is that they increase feelings of satiety more than foods high in other macronutrients. This could be a problem if increasing protein intake leads to decreasing intake during the rest of the day. A body of evidence shows that protein is associated with weight management by staving off hunger and decreasing subsequent energy intake (Halton & Hu, 2004; Hill & Blundell, 1986; Paddon-Jones et al., 2008; Skov, Toubro, Rønn, Holm, & Astrup, 1999; Weigle et al., 2005). Older adults are known to show lower levels of compensation for energy intake than younger adults (Appleton, Martins, & Morgan, 2011; Rolls, Dimeo, & Shide, 1995), but not much is known about the satiety effects of protein in the elderly specifically. There is some evidence that older adults can feel full longer than young adults after a high protein preload (Wilson, Purushothaman, & Morley, 2002), although other studies have shown a low level of compensation in older adults at a subsequent meal after increased protein intake (Appleton, 2017a; Giezenaar et al., 2015; Smoliner et al., 2008; Stelten et al., 2015). A meta-analyses on the effect of high-protein (>20% energy from protein) oral nutritional supplements (ONS) found little suppression of normal food intake in older adults (Cawood, Elia, & Stratton, 2012).

2.2 Eating behaviour in older adults

The above section reviewed the importance of increasing protein intake in older adults. The next section reviews literature about the specific factors that may be related to changing eating behaviour in older adults. Because changing eating behaviour, and subsequently health status, is complicated by the many different factors that simultaneously affect food choice, it is important to investigate the specific barriers and facilitators for eating behaviour in community dwelling older adults. Some of the factors thought to be specific to older adults are reviewed in the following paragraphs.

2.2.1 Anorexia of ageing

One of the factors which may influence eating behaviour in older adults is the loss of appetite. When people get older they tend to lose their appetite, eat slower and eat smaller portions (Hetherington, 1998; Nieuwenhuizen et al., 2010). Lower energy intake is likely to result in weight loss and muscle mass loss, and a higher risk of not meeting micronutrient requirements. Food intake for adults decreases 25% from 40 years old to 70 years old (Nieuwenhuizen et al., 2010). There are a number of reasons why older people tend to eat less food or different foods than younger adults (Donini, Savina, & Cannella, 2003; Hetherington, 1998; Nieuwenhuizen et al., 2010; Roy, Gaudreau, & Payette, 2016). Previous studies have explored determinants for eating in older adults (Falk, Bisogni, & Sobal, 1996; Locher et al., 2009; Steptoe, Pollard, & Wardle, 1995). Older adults are more susceptible to energy imbalance, positive as well as negative (Roberts & Rosenberg, 2006). Physiological changes (Wilson & Morley, 2003), but also psychological and social reasons (Donini et al., 2003; Roy et al., 2016) may lead to a reduced appetite and weight loss (especially lean body mass), often referred to as the ‘anorexia of ageing’. Therefore, it is very important for older adults to eat high quality nutrient dense foods. Eating a lower quantity and/or quality of foods can result in malnutrition. The prevalence of being at risk of malnutrition was between 11.2% and 19.4% for British individuals over 65 years old living in the community or in residential accommodation (Elia & Stratton, 2005), and has been measured to be as high as 33.2% to 50% for older adults in residential care and nursing care (Norris, Shelton, & Hetherington, 2011). However, despite the popular idea that malnutrition develops in hospitals or care homes, the majority (93%) of those at risk of malnutrition live in the community (Elia & Russell, 2008).

2.2.2 Sensory abilities

Sensory impairment can be a specific barrier to eating in older adults. The sensory (or organoleptic) characteristics of a food, like the flavour, odour or texture, have been shown to be important factors affecting food choice in general in older adults (Steptoe et al., 1995). The taste and texture of ONS have shown to be strongly related to liking for and intake of the product in older adults (Gosney, 2003; Kennedy et al., 2010). Consequently, different types of studies have shown that changing the sensory characteristics of food can increase intake or liking (Cassens, Johnson, & Keelan, 1996; Mathey, Siebelink, de Graaf, & Van Staveren, 2001). The ability to smell, taste, or feel texture of food may change when people get older, and can affect eating behaviour.

The aging population tends to face different problems that affect mastication and consequently sensory abilities, including: dentition, mouth dryness (salivation), dysfunctioning of tongue motor skills and swallowing (Peyron, Woda, Bourdiol, & Hennequin, 2016). Additionally, slower turnover of sensory cells, a decreased speed of the nervous signal, can lead to a reduction in number and functioning of sensory receptors (Sulmont-Rossé et al., 2015). It has been suggested that sensory impairment is associated with the quality and quantity of food intake in older adults (Aschenbrenner et al., 2008; Doets & Kremer, 2016; Schiffman & Graham, 2000). The different sensory perceptions (gustatory, olfactory, somatosensory) generally tend to change with ageing (Doets & Kremer, 2016). Beyond the general trend that chemosensory abilities decline with age there seems to be a large variability between the sensory abilities of older adults (Kremer, Bult, Mojet, & Kroeze, 2007; Mattes, 2002; Sulmont-Rossé et al., 2015); extensive literature shows that the effect of sensory abilities on food choice is very complex. The variability in sensory abilities among older adults is greater than among younger adults (Koskinen, Kälviäinen, & Tuorila, 2003b). Impairments in sensory abilities have been shown to differ with health, independently of the effect of age, including use of medication, dentition and oral health, and functional ability and independence (de Jong, Mulder, de Graaf, & van Staveren, 1999; Gopinath, Anstey, Kifley, & Mitchell, 2012; Griep et al., 1997; Kremer, Bult, et al., 2007; Mackay-Sim, Johnston, Owen, & Burne, 2006; Sulmont-Rossé et al., 2015) Moreover, the different sensory abilities (e.g. olfactory and gustatory) do not always decline simultaneously (Sulmont-Rossé et al., 2015), and may be different for different foods (Kremer, Mojet, & Kroeze, 2005, 2007).

Although taste detection thresholds are higher in elderly adults than in younger adults, older adults show less sensitivity to flavour profile changes, and are less able to discriminate different flavour intensity levels, they do not show differences in optimal preferred concentrations (Doets & Kremer, 2016; Kremer, Bult, et al., 2007; Methven, Allen, Withers, & Gosney, 2012; Mojet, Christ-Hazelhof, & Heidema, 2005). This indicates that simply increasing flavour intensity does not necessarily increase liking for the food. Although it seems intuitive to assume sensory deterioration with age changes food liking and food choice, there is not much data to support this (Mattes, 2002). Kremer et al. give several potential explanations for this. It is likely that with gradual sensory deterioration food liking stays similar because of habituation to the decreased perception. Moreover, the sensory and hedonic responses are in different areas of the brain (Kremer, Mojet, et al., 2007).

2.2.3 Physical abilities

Another potential barrier to eating in older adults is their physical ability to prepare a meal. Physical abilities have also been shown to affect eating behaviour (Locher et al., 2009). Elderly may struggle with food purchasing, e.g. getting to the shop, food preparation, e.g. being able to stand for long enough to prepare a meal, and have the functional ability/dexterity to prepare different foods (Appleton, 2016; Best & Appleton, 2013; Hughes, Bennett, & Hetherington, 2004; Millwood & Heath, 2000; Wylie, Copeman, & Kirk, 1999). Previous work shows that significantly fewer women with rheumatoid arthritis cook their own meals compared to other women without or with milder rheumatoid arthritis (Allaire, Meenan, & Anderson, 1991). Qualitative work showed that community dwelling elderly people with restricted mobility have an infrequent consumption of cooked meals, and difficulties with food preparation and shopping were specifically reported as factors affecting food choice and dietary intake (Best & Appleton, 2013; Wylie et al., 1999). Good cooking skills have been associated with better physical health in UK older men living on their own (Hughes et al., 2004), and in community dwelling Taiwanese elderly greater cooking frequency was associated with lower mortality rates (Chen, Lee, Chang, & Wahlqvist, 2012).

2.2.4 Eating abilities

Eating abilities or eating capabilities have been reported in the literature as a potential barrier to eating in older adults. Eating capabilities, e.g. biting, chewing, or

swallowing, are often compromised by oral health, denture status, and salivary function, and affect nutritional status and food choice (Appleton, 2016; Best & Appleton, 2013; Sheiham, Steele, Marcenes, Tsakos, et al., 2001; Smith & Gray, 2016; Walls & Steele, 2004). Chewing efficiency is lower in older adults than younger adults (Kälviäinen, Roininen, & Tuorila, 2003; Kremer, Mojet, et al., 2007), and eating difficulties are correlated with the risk of malnutrition in the elderly (Maitre et al., 2014). A qualitative study found that 69% of the edentate elderly that they interviewed indicated having difficulty eating at least one type of food, and that half of the participants did not want to eat the foods they found difficult to eat (Millwood & Heath, 2000).

All these influences on eating behaviour concerning physical health are likely not to occur in isolation and might overlap. It has been shown that grip strength is linked to oro-facial muscle strength, and correlates with tongue pressure and biting force (Laguna, Sarkar, & Chen, 2015). Since low grip strength is an indication of frailty and muscle loss (Lauretani et al., 2003), this suggests that eating difficulties may be a common problem among the frail elderly. Lastly, older adults with olfactory impairment are significantly more likely to also have impaired functional ability, less independence, and more difficulty with activities of daily living (Gopinath et al., 2012).

There are some indications that some of the above physical impairments can be overcome, e.g. by using different preparation techniques to make difficult to chew foods softer (Kossioni & Bellou, 2011), or by adding sauce which may change the flavour and ease to chew (Appleton, 2009; Best & Appleton, 2011). However, these strategies may be limited by culinary skills and willingness to change behaviour.

2.2.5 Changing eating behaviour in older adults

Willingness to change eating behaviour may be a factor influencing eating behaviour in older adults. Eating behaviour is habitual, and habits play an important role in compliance to dietary recommendations (van't Riet, Sijtsema, Dagevos, & De Bruijn, 2011). This might especially apply to behaviour change interventions directed at older adults, because eating habits tend to develop from an early age (Nicklaus, Boggio, Chabanet, & Issanchou, 2005). Eating behaviour of the elderly is strongly driven by habits and past eating behaviour (Edfors & Westergren, 2012; McKie, MacInnes, Hendry, Donald, & Peace, 2000). Elderly may be more

susceptible to the habitual intake of foods because they do not experience boredom when repeatedly exposed to the same food, while younger adults do increase ratings of boredom (Essed et al., 2006).

Food neophobia is the reluctance to eat and/or avoidance of novel foods, mainly thought to affect children between two and six years old, and be stable during adulthood (Dovey, Staples, Gibson, & Halford, 2008; Pliner & Hobden, 1992). There are some indications, however, that food neophobia increases in older adults (Meiselman et al., 2010; Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001). Although Pelchat and Stoess showed the opposite effect with older adults being more willing to try new foods (Pelchat & Stoess, 1991), they later showed that impaired olfaction might play a role in their willingness to try unpleasantly smelling foods rather than food neophobia (Pelchat, 2000). Maitre et al (2014) found that 23% of the elderly in their survey were picky eaters, and that food pickiness in elderly populations is correlated with increased risk of malnutrition and dependency. If introducing an unfamiliar/novel food may be more difficult for older adults, it will be easier to encourage increasing protein intake using protein rich foods that are familiar to them.

The ‘Behaviour change wheel’ developed by Michie and colleagues demonstrates that behaviour change interventions that either address challenges or maximise facilitators will have increased chances of success compared to those less developed (Michie, Van Stralen, & West, 2011). Furthermore, interventions that focus on challenges or facilitators that impact on a large proportion of the population will be of increased impact on a population-wide scale (Craig et al., 2008).

2.2.6 Familiarity

Many studies about protein intake and muscle mass use isolated protein supplements (e.g. (Cuthbertson et al., 2005; Moore et al., 2014)). However, other studies have suggested that the acceptance of unfamiliar foods can be low in older adults (Edfors & Westergren, 2012; Laureati, Pagliarini, Calcinoni, & Bidoglio, 2006; McKie et al., 2000; Meiselman et al., 2010; Tuorila et al., 2001). It has been shown that ONS are often disliked (Gosney, 2003; Kennedy et al., 2010) . Studies show that even protein enriched foods are not acceptable to many older adults, and that they prefer conventional protein rich foods over enriched foods to increase their protein intake (van der Zanden et al., 2014a, 2015).

The British Association for Parenteral and Enteral Nutrition (BAPEN) developed a project recommending a “food first” approach (BAPEN, 2017). Prescribing ONS is widely recommended in the management of malnutrition, but a meta-analysis showed that the effectiveness of dietary counselling with or without ONS is comparable in increasing energy intake or weight in malnourished patients (Baldwin & Weekes, 2012). While the flavour of ONS has been rated as pleasant and comparable to familiar foods/drinks by community dwelling older adults (McAlpine, Harper, McMurdo, Bolton-Smith, & Hetherington, 2003), intake and acceptability of ONS are low among hospital patients who are prescribed ONS (Gosney, 2003). It has been shown that enrichment of meals with conventional foods (e.g. cream or cheese) could increase the energy density of meals, and increased energy intake with about 30% (Olin et al., 2003). Unfortunately, the study focused on energy intake and not on increasing protein, the test meals were comparable in protein content (Olin et al., 2003).

There are some studies with conventional foods and mixed meals, but they are often of lower protein content and often focussed on protein intake for two meals per day (Alemán-Mateo et al., 2014; Daly et al., 2014; Murphy et al., 2016). Increasing protein for three meals per day may potentially be challenged by finding high protein foods that are acceptable for breakfast. The foods studies used to increase protein intake may not be appropriate or acceptable in the UK as a breakfast food (e.g. lean red meat, (Daly et al., 2014; Torres et al., 2017), or ricotta cheese (Alemán-Mateo et al., 2014)).

2.2.7 Determinants specific to protein intake in older adults

Previous studies have explored determinants for eating protein rich foods, including sensory characteristics, physical abilities involved in food preparation and food shopping, and eating capabilities, e.g. biting, chewing, or swallowing, (Appleton, 2016; Best & Appleton, 2013; Deutz et al., 2014; Volpi et al., 2013). For certain protein rich foods such as meat, cooking, biting and chewing can be difficult and studies show that older adults avoid eating meat and nuts (Fucile et al., 1998). Specifically, older adults with difficulty chewing report avoiding chewy/stringy foods like meat (Hildebrandt, Dominguez, Schork, & Loesche, 1997), and having a lower intake of beans and nuts (Kimura et al., 2013), and meat/meat dishes and total protein intake (Holmes & Roberts, 2011; Holmes, Roberts, & Nelson, 2008), while consuming more softer foods (including chicken, fish, grains, and dairy products)

(Kossioni & Bellou, 2011). Moreover, for foods that are difficult to chew like meat, the chewing ability of older adults (Rémond et al., 2007) as well as the processing method (minced beef vs beef steak) (Pennings et al., 2013) can affect the postprandial digestion and absorption rates of the protein, suggesting older people would benefit more optimally from a protein source they can chew more easily.

2.3 Egg consumption in older adults

The above sections reviewed literature on increasing protein intake in older adults, the importance of high quality protein, that is easy to chew and prepare in case of limited physical impairments. The next section will review why eggs may be of help in increasing protein intake in older adults, and which factors may influence egg intake in older adults.

2.3.1 Eggs as a source of protein

Eggs are a nutrient dense, high quality source of protein (Ruxton et al., 2010; Smith & Gray, 2016). Sensory analyses with older adults have previously shown that eggs were popular for their soft texture, while different types of meat were characterized to have more difficult textures (tough, dry and/or stringy) (Rousset & Jolivet, 2002). Compared to other protein-rich foods, eggs are also easy to cook, of long shelf-life and low cost (Drewnowski, 2010; Lewis & Bashin, 1988). Moreover, they are generally acceptable breakfast food (Smith & Gray, 2016), which is a meal that is often low in protein (Tieland, Borgonjen-Van den Berg, et al., 2012).

2.3.2 Nutritional values of eggs

Eggs are a high protein, nutrient dense food, relatively low in energy and saturated fatty acids (Ruxton, Derbyshire, & Toribio-Mateas, 2016). A medium sized egg (58g) contains about 66kcal, 6.4g of protein, and 177mg of cholesterol, 4.6g total fat of which 1.3g saturated fat (McCance & Widdowson, 2002). The nutritional values of eggs have changed over the years due to changes in the diet of hens; vitamin D has increased by 64%, while cholesterol and saturated fat levels are decreased by 13% and 23% (McCance & Widdowson, 2002). The European Commission Nutrition and Health Claims regulation defines a ‘source’ as containing at least 15% of the RDA per 100g, and ‘rich in’ as containing at least 30% of the RDA per 100g (Regulation,

2007). Following this, eggs are a ‘source’ of vitamin A, folate, choline, phosphorus and selenium; and ‘rich in’ vitamin D, riboflavin, vitamin B12, biotin and iodine. Eggs also contain the polyunsaturated fatty acids alpha linolenic acid (ALA) and docosahexaenoic acid (DHA).

Some of the above nutrients have been associated with sarcopenia, physical strength and functioning and other health benefits. Vitamin D supplementation is known to reduce the risk of falls and fractures in elderly (Bischoff-Ferrari et al., 2009; Bischoff-Ferrari et al., 2004; Bischoff-Ferrari et al., 2005; Chapuy et al., 1992), which might be explained by the relation between vitamin D and muscle strength, muscle function and sarcopenia (Bischoff et al., 1999; Janssen, Samson, & Verhaar, 2002; Millward, 2012; Visser, Deeg, & Lips, 2003). Vitamin D intake is known to be very low among older adults (Ruxton et al., 2016). Eggs are rich in vitamin D with two eggs providing 37% of the recently increased RNI (British-Nutrition-Foundation, 2016). For choline, eggs are the highest natural food source (Patterson et al., 2008), and therefore could make a significant contribution to choline intakes. Choline intakes have been related to cognitive functioning in older adults (Moreno, 2003; Poly et al., 2011). Selenium intake in older adults has been linked to muscle strength (Beck et al., 2007; Lauretani et al., 2007), and also to Alzheimer’s disease (Reddy, Bukke, Dutt, Rana, & Pandey, 2017), cognitive decline (Akbaraly et al., 2007; Cardoso, Bandeira, Jacob-Filho, & Cozzolino, 2014), and mortality (Alehagen et al., 2016). In the NDNS 24-33% of males and 41-61% of females had selenium intakes below the Lower Reference Nutrient Intake (LRNI) (Bates et al., 2014). Older adults often show a high saturated fat intake and low unsaturated fat intake (Ruxton et al., 2016). It has been suggested that polyunsaturated fatty acids can counteract ‘anabolic resistance’ and could be used in the treatment and prevention of sarcopenia (Di Girolamo et al., 2014). Omega-3 fatty acid supplementation can increase MPS in older adults (Smith et al., 2011), and has been associated with improved grip strength (Calder, 2006; Robinson et al., 2008). Fish oil (rich in PUFAs) has also been associated with improved muscle strength and functional performance in combination with strength training compared to only strength training (Rodacki et al., 2012). Eggs can contribute to the food-based intake of the carotenoids lutein, and zeaxanthin (Eisenhauer, Natoli, Liew, & Flood, 2017). The concentrations of antioxidants lutein and zeaxanthin can be significantly increased with the consumption of one egg per day (Goodrow et al., 2006; Kishimoto et al., 2017). Serum concentrations of lutein and zeaxanthin have been associated with better cognitive function (Feeney et al., 2017), and with

reduced risk of age related macular degeneration (AMD) (Chew et al., 2014; Eisenhauer et al., 2017).

An epidemiological study examining the nutritional contributions of egg to the quality of total diet indicates that adults eating four eggs per week or more had a higher micronutrient intake than those who did not eat eggs, while having lower cholesterol levels (Song & Kerver, 2000). It has also been suggested that the lipid matrix of an egg can increase the bioavailability of the nutrients (Herron & Fernandez, 2004).

2.3.3 Eggs and satiety

People's knowledge or experience with the satiety of eggs could be a facilitator or a barrier to eating eggs, in case they are trying to manage their weight or if they think they are too filling. Several studies examining the influence of eggs on satiety and weight management, show that egg intake seems to affect self-reported hunger/fullness scores, and appetite hormones, but did not affect energy intake at a subsequent meal (Bayham, Greenway, Johnson, & Dhurandhar, 2014; Fallaize, Wilson, Gray, Morgan, & Griffin, 2013; Pombo-Rodrigues, Calame, & Re, 2011; Ratliff et al., 2010; Vander Wal, Marth, Khosla, Jen, & Dhurandhar, 2005). Missimer et al. showed that 2 eggs compared to oatmeal for breakfast increased self-reported hunger/fullness scores and decreased plasma ghrelin levels, subsequent intake was not measured (Missimer et al., 2017). When directly comparing equal amounts of protein as eggs and cottage cheese, amino acids in eggs were digested slower, and affected hormone secretion differently (Marsset-Baglieri et al., 2015), which may indicate that the specific amino acid composition could influence speed of digestion, although there was no difference in reported hunger/fullness ratings and subsequent intake. Moreover, some studies show egg intake was related to reduced subsequent intake (Leidy, Ortinau, Douglas, & Hoertel, 2013), or reduced body weight (Vander Wal, Gupta, Khosla, & Dhurandhar, 2008). Another recent study showed that overweight or obese people (with type 2 diabetes) on a diet high in eggs (two eggs a day for 6 days a week) reported less hunger and greater satiety after breakfast with eggs than the group with equal protein intake but low egg intake (Fuller et al., 2015).

2.3.4 Eggs and Salmonella

A possible barrier to eating eggs that may be specific to the generations in the target age group of this PhD is the salmonella scare. The salmonella food scare from the late 1980s had a major effect on egg sales in the decades to follow. At that time the target group was older than 28 years old (if they were over 55 years old in 2015) and may have been affected by it. In 1988, UK egg consumption dropped by 60% overnight when Health Minister Edwina Curry warned people that most British egg production is infected with salmonella (BBC-news, 1988; British-Egg-Industry-Council, 2016b). Despite the lack of evidence for her announcement, the drop of Salmonella cases with the introduction of the British Lion Scheme, and various campaigns to promote eggs, the egg's reputation for potential health threats was long lasting. It took until 2014 to get egg consumption back to the level it was before the Salmonella scare (Poulter, 2015). A recent update on the microbiological risk from eggs by the Advisory Committee on the Microbiological Safety of Food (ACMSF) recommends that "Lion code eggs (or eggs produced under equivalent schemes) can be served raw or lightly cooked to those in vulnerable groups, including pregnant women, the young and the elderly" (Coia et al., 2016).

2.3.5 Eggs and cholesterol

Another barrier to increasing intake of eggs may be people's fear of increasing blood cholesterol levels and risk of coronary heart disease (CHD). There is now strong evidence showing that cholesterol from foods has only a small and clinically insignificant effect on serum cholesterol (McNamara, 2000), and based on this the recommendations for restricting egg intake were changed in 2007. The British Heart Foundation now does not have a recommended limit on amount of eggs per week. With the exception of people with familial hypercholesterolaemia, who are still recommended to restrict their dietary cholesterol and egg intake to no more than three or four eggs a week (British-Heart-Foundation, 2015). The latest versions of the European Guidelines on Cardiovascular Disease Prevention in Clinical Practice (Piepoli et al., 2016) include "The impact of dietary cholesterol on serum cholesterol levels is weak compared with that of the fatty acid composition of the diet.", and therefore do not give specific guidelines on the intake of dietary cholesterol. The problem however is that the "myth" or misconception that eggs are bad for blood cholesterol, and with this the risk of CHD, persists in the minds of many people and may even still influence the advice of some professionals (Gray & Griffin, 2009; Griffin, 2016). This perception may still be a barrier to eating eggs in older adults.

2.3.6 Eggs and diabetes

Some older adults may limit their egg intake because of the perception that it could be related to diabetes type 2. Although studies have found associations between egg intake and type 2 diabetes or egg intake and risk of CHD or mortality in people with type 2 diabetes (Djoussé & Gaziano, 2008; Houston et al., 2011; Hu, Stampfer, Rimm, et al., 1999; Li, Zhou, Zhou, & Li, 2013; Rong et al., 2013; Shin, Xun, Nakamura, & He, 2013) (Djoussé, Gaziano, Buring, & Lee, 2009; Shi, Yuan, Zhang, Zhou, & Holmboe-Ottesen, 2011). Other studies do not find these associations (Djoussé et al., 2010; Djoussé et al., 2016; Fuller et al., 2015; Kurotani et al., 2014; Zazpe et al., 2013). The previously found positive associations might have been mediated by the fact that higher egg consumption tends to be associated with unhealthy lifestyle factors which are also associated with type 2 diabetes, e.g. smoking and physical inactivity, and unhealthy eating patterns including high intakes of SFA, total energy and intake of processed- and red meats (Djoussé et al., 2009; Hu, Stampfer, Rimm, et al., 1999; Ruxton et al., 2010).

2.3.7 General determinants of egg intake

Lastly, a few studies have shown determinants for eating eggs in younger adults. Consumer research in younger adults shows that determinants for buying and eating eggs include: convenience, easy preparation, versatility, freshness, quality, long shelf life, good price/value for money, animal welfare concern, origin of the product, sensory aspects (e.g. taste, texture), habit, nutritional value, environmental impact, and cholesterol (Fearne & Lavelle, 1996b; Hernandez, 2006; Lewis & Bashin, 1988). Many of these can also be found as determinants for general food choice in elderly (Locher et al., 2009; Nieuwenhuizen et al., 2010; Steptoe et al., 1995), or determinants of the intake of protein rich foods in older adults (Best & Appleton, 2013). However, barriers and facilitators for food intake are likely to vary with age (Bejaei, Wiseman, & Cheng, 2011; Steptoe et al., 1995) and different foods (Appleton, 2016). It is unsure whether the above reasons would also apply to egg consumption in older adults.

2.4 Summary

Section 2.1 describes how British older adults eat less, and eat less protein than younger adults. The prevalence of protein specific under nutrition is high. Dietary protein can have an important impact on muscle mass and muscle strength, and other health outcomes that are likely to affect the elderly population. Although the protein intake recommendations vary, and measured requirements differ depending on which methods are used, there are strong suggestions that many older adults may benefit from increasing dietary protein intake. The suggested higher recommended protein intake for older adults is 1-1.2g of high quality protein per kg of body weight per day. On top of the daily intake recommendations, a protein intake of 25-30g per meal (or 0.4g/kg of body weight) is recommended for optimal health benefits.

Studies have demonstrated that protein intake distribution over the day is generally skewed to the main meal (a hot meal at either lunch or dinner time) and particularly low for breakfast. Every extra meal per day of reaching the optimal protein threshold is associated with significantly higher muscle strength and lean body mass, and therefore more health benefits. With the UK older population increasing rapidly, it has become increasingly relevant to maintain or improve health and wellbeing in later years.

Section 2.2 reviews the specific challenges for increasing protein intake in older adults. As people get older, they tend to lose their appetite, eat slower and eat smaller portions, and consequently lose weight and/or muscle mass and function. Eating behaviour in older adults is also specifically affected by potential physical difficulties with purchasing or preparing food, eating capabilities (e.g. biting, chewing, swallowing), and sensory impairments related to eating (e.g. olfactory and gustatory). Additionally, older adults may be less willing to change eating behaviour as they get older, especially when foods are unfamiliar to them (e.g. ONS).

Section 2.3 presented literature about egg consumption in older adults. Increasing egg intake is suggested as a strategy to increase protein intake. Compared to other protein rich foods, they are of soft texture, easy to cook, of long shelf-life and low cost. Eggs are a nutrient dense, high quality source of protein. The satiety effects of eggs may be a factor influencing people's choice to eat eggs or not. Additionally there are several barriers specific to the consumption of eggs in older adults. The

UK salmonella scare may affect people’s egg consumption, and fear of cholesterol content, coronary heart disease and type 2 diabetes may be another barrier to eating eggs. Lastly, there are several determinants of egg consumption in younger adults, but it is unsure whether these determinants would also apply to egg consumption in older adults.

3. Exploring the reasons for eating or not eating eggs in older adults: a focus group study

3.1 Introduction

Chapter 2 describes the importance of dietary protein intake for older adults (Bauer et al., 2013; Deutz et al., 2014; Wolfe et al., 2008). The prevalence of protein specific under-nutrition in community dwelling older adult can be as high as 77% depending on which recommendations are used (Berner et al., 2013; Fulgoni, 2008; Jyväkorpi et al., 2015; Tieland, Borgonjen-Van den Berg, et al., 2012). The literature review also discussed that many older adults could benefit from increasing dietary protein intakes (Bauer et al., 2013), and that eggs may be of help in increasing protein intake in older adults.

There are a number of physiopathological, psychological, and social reasons why older people tend to eat less food or different foods than younger adults (Donini et al., 2003; Hetherington, 1998; Nieuwenhuizen et al., 2010; Roy et al., 2016) , including the anorexia of ageing, change in sensory abilities, physical abilities and eating abilities discussed in chapter 2. For protein-rich foods specifically, it has been suggested that intakes in older adults are strongly related to perceived convenience, perishability, and value for money (Appleton, 2016). Compared to other protein-rich foods, eggs are easy to cook, of long shelf-life and low cost (Drewnowski, 2010; Lewis & Bashin, 1988). They are of soft texture and therefore may be relatively easy to eat for older adults.

Changing eating behaviour, and subsequently health status, is complicated by the many different factors that simultaneously affect food choice. Previous studies have explored determinants for eating in general in older adults (Falk et al., 1996; Locher et al., 2009; Steptoe et al., 1995), and for eating protein rich foods specifically (Appleton, 2016; Best & Appleton, 2013). Moreover, the determinants of egg intake have been studied in younger adults (Fearne & Lavelle, 1996a, 1996b; Hernandez, 2006).

However, to the author's knowledge there are no qualitative studies identifying the reasons specific to eating or not eating eggs in British community dwelling older

adults. Determinants reported in the existing literature could only be used making assumptions on whether determinants of general food choice will also apply to eggs, and/or whether the determinants for egg consumption in younger adults would also apply to older adults. Instead, this PhD project is designed to use qualitative research to understand why people in this target age group eat or do not eat eggs.

A good understanding of the self-perceived barriers and facilitators to choosing eggs in older adults could help in a food based approach to improve or maintain protein status. Therefore this study aimed to explore the reasons for consuming and not consuming eggs among British adults over the age of 55.

3.2 Methods

The study was conducted using focus groups and interviews to allow the elicitation of as many reasons for eating or not eating eggs as possible without constraining ideas and responses. Rather than using determinants for food choice from the literature and apply them to egg intake in older adults, a more inductive approach was used to understand why people in this target age group eat or do not eat eggs. Food intake is not just about the physical need for energy, but can have a complex role in a person's life (Chamberlain, 2004; Swift & Tischler, 2010). Qualitative research is especially suited for exploring why people behave/eat in a certain way (Swift & Tischler, 2010). Thematic analysis was thought to be most appropriate for the objective and research question of this study, because the study was aimed to find the explicitly mentioned reasons for eating or not eating eggs in older adults. The topics discussed were not expected to be sensitive to participants; participants were therefore expected to feel comfortable to discuss their viewpoints in a group. Focus groups are especially likely to prompt group interaction, and subsequently focus on the group's attitudes, understanding, language, and the group norms (Kitzinger, 1994), which was thought to provide a more in depth discussion. Moreover, the role of the researcher (or moderator) is smaller in focus groups than in individual interviews. In case there may be reasons that would not be discussed in a group, two individual interviews were also conducted. Ethical approval was granted by the Research Ethics Committee of Bournemouth University, prior to commencement.

3.2.1 Participants

People were included if they were aged 55 years old and over, able to give consent, not allergic to dairy products, nuts, eggs, meat products or seafood, had not been undergoing chemotherapy or radiotherapy in the last 6 months, did not currently suffer from any serious condition which they felt influenced their eating and had choice over their food intake. An allergy, medical condition or treatment would have a big impact on eating behaviour and people suffering from this would have different reasons for eating or not eating than others (Jcobsen et al., 1993; Steinbach et al., 2009; Van Cutsem & Arends, 2005). Eating behaviour specific to allergies and medical conditions or treatments is beyond the scope of this project.

Recruitment focussed on individuals independently living in their own homes. Additionally, one focus group was planned with participants living in warden-assisted sheltered housing and one focus group in a residential (non-nursing) care home (provided inclusion criteria were met) to increase the diversity of the population sample and the diversity of reasons for consumption/non-consumption considered. Participants living in warden-assisted sheltered housing live independently and in the community, but are also supported by 24hr wardens and greater community support. Residents of the care home did not prepare their own food, but alternatives or additions to any meal (including the use of eggs) were always possible.

Independently living participants were recruited from the local community by contacting people in the target age group who have volunteered in previous studies, organisations that run group meetings with people in the target population, as well as word of mouth. Sheltered housing and care home residents were recruited via the management team. The managing staffs were asked which residents were thought to be most suitable for the study, and would be able to give informed consent. The staff members then recruited the people they thought would be interested and able to do this. At the time and day agreed upon with the team leader/manager, the assigned residents received more information about the study and were asked to sign individual informed consent if they were still interested to take part.

Because the target age group is heterogeneous in lifestyle, physical abilities and eating behaviour (den Uijl et al., 2014; van der Zanden et al., 2014b), the participants were recruited to be representative of different types of older adults.

Community dwelling older adults who were interested to participate were contacted before the focus groups to record gender and employment status (working >20h or not). Frailty levels were also recorded to ensure the study included older adults who were frail and older adults who were not frail (2001). The definition used for frailty was taken from Fried et al (2001). People were considered frail if they self-report to meet three or more of the following criteria: Having suffered from unintentional weight loss of more than 10 lbs in the past year; Often feeling exhausted (i.e. often feeling that everything they do is an effort, or that they cannot get going); Suffering from weakness (in grip strength); Slow walking speed; Low physical activity. Focus groups were designed to be mixed, or include exclusively males, females, people who work (more than 20 hours per week), and people who do not work, and individual interviews included one male and one female. Discussion exclusively among these groups may reveal reasons for consumption / non-consumption that would otherwise remain hidden (Krueger, 2014). Gender and working habits are known to impact on food choice (Appleton, McGill, & Woodside, 2009; Donkin et al., 1998; Helldán, Lallukka, Rahkonen, & Lahelma, 2011; Jabs & Devine, 2006; Steptoe et al., 1995; Wardle et al., 2004). Working more than 20 hours per week affects daily routine and limits time available for food shopping and preparing, which may affect food choice (Jabs & Devine, 2006). Frailty is thought to impact eating behaviour through potential difficulties with shopping for and preparing foods, or eating itself, e.g. biting, chewing, and swallowing (Best & Appleton, 2013; Locher et al., 2009; Sheiham, Steele, Marcenes, Lowe, et al., 2001).

The participants were deliberately not informed the project was about protein or eggs, nor whether these foods were thought to be good or harmful for them. This was done to not give them the opportunity to look up information to prepare for the discussion, to reduce volunteer bias by preventing people who do not like eggs to not participate, and to reduce the potential bias of demand characteristics where participants may perform in a way they think is expected from them.

3.2.2 Procedure

Community dwelling participants were contacted before the focus group meeting to ask about inclusion criteria and note gender, work status and frailty level, and to invite them to participate in different discussion groups accordingly.

The focus groups and interviews with community dwelling elderly were held at Bournemouth University. One or two researchers were present (a moderator (the researcher) and with the bigger groups also an assistant (PhD supervisor)). Both researchers were aware of the background of the study and the study's aim and objectives. Focus groups and interviews were semi structured, and each lasted approximately one hour. The discussions were audio recorded on two digital recorders positioned at different places in the room. Participants were given information sheets and a written and oral explanation of the study's procedure and data handling. All participants signed a consent form before the initiation of the focus group discussion.

Each meeting started with a short introduction to the researcher(s), an explanation of the study procedure and an explanation of the audio recording, anonymity and confidentiality. Participants were then asked to introduce themselves and talk a little about their last meal that was particularly memorable. This encouraged everyone to feel comfortable and start talking. Following this, participants were asked to discuss whether they thought their age, or their daily routine (e.g. working or not working) influenced their eating (in general) to prompt them to think about whether their lifestyle influences their eating. Participants were then shown twelve pictures of eggs prepared in different ways: hard and soft boiled eggs, fried eggs, scrambled eggs, omelette, stuffed/devilled egg, pickled eggs, scotch eggs, quiche, eggnog, crème caramel and egg custard tarts. The moderator discussed with the group what all the pictures represented and that the pictures were just to remind them to think of all the different ways in which eggs can be eaten. The participants were asked what they thought about eggs, why they do or do not eat eggs, and/or what their reasons are for eating or not eating eggs, or eating or not eating eggs in a certain way. Participants were then shown another set of six pictures showing protein rich food groups (eggs, meat, fish/seafood, dairy/cheese, nuts, and pulses), and the participants were asked how the reasons for consumption already mentioned may differ between eggs and the foods in the pictures. The discussion ended by discussing whether participants were willing to replace any of the foods in the pictures with egg, or any other foods, and whether they would consider eating more eggs. These questions aimed to evoke any new reasons that had not been mentioned previously.

At the end of the session, each participant had his/her height and weight measured by the experimenter (or self-reported this where they did not feel comfortable being

measured), and all participants filled out a short questionnaire on demographic information and lifestyle factors, requesting: marital status, living situation, education level, nationality, (previous) employment level, whether they are vegetarian or vegan, whether they have (partial or full) dentures, whether they have physical disabilities that hinder food purchasing, food preparing, food consumption, and whether they do their own food shopping or preparation, receive help with food shopping or preparation, have food delivered, or eat away from their home. Having made sure there was nothing else anyone would like to mention, the experimenter debriefed the participants about the background of the study. The questioning route can be found in appendix 3.1. Focus groups were conducted until no new reasons emerged, indicating that data saturation was reached.

The focus groups with sheltered housing and care home residents were not held at Bournemouth University, but in a common room at the accommodation where the participants live. This was believed to be easier and more comfortable for the participants. The procedure was very similar to the procedure of community dwelling focus groups. Special attention was paid to signs of fatigue to offer breaks accordingly.

3.2.3 Data analyses

Audio-recordings were transcribed by the moderator of all focus groups and interviews. The analytical strategy used in this study is based on the principles of thematic analysis by Braun and Clarke (Braun & Clarke, 2006). This exploratory study did not test a hypothesis but took an inductive, or data driven approach. Both researchers involved in analysis have background knowledge in eating behaviour and the determinants of food choice which may have affected analyses. However, there were no a priori reasons set out before the data was analysed, and the quotes were not grouped together to fit pre-defined categories. Open-ended questioning was used to allow the participants to share their ideas and experiences spontaneously. For this study the aim is not to look for underlying meaning, semantic sub-themes were identified based on the explicit meanings of the quotes. Analyses focussed exclusively on references to eggs or protein-rich foods; comments about eating behaviour in general were not considered. Reasons for eating eggs were coded separate from reasons mentioned referring to other protein rich foods. The discussions about people's willingness to eat more eggs were not

analysed separately, but were screened for reasons for eating or not eating eggs or protein rich foods.

To start the thematic analysis, researchers familiarized themselves with the data. In this project the generating of sub-themes was done by two researchers independently. One of the researchers was the moderator of all the focus groups and interviews, and performed the transcribing of all audio recordings. This is described as an “excellent way to start familiarizing yourself with the data” (Riessman, 1993 via (Braun & Clarke, 2006)). The other researcher assisted in most of the focus groups. Quotes were coded to the sub-themes using the qualitative data analysis software NVivo (QSR International Pty Ltd. Version 10, 2012). Quotes from the transcripts were assigned to sub-themes. Labels and definitions were developed, altered and refined guided by the phases of thematic analysis described by Braun and Clarke (Braun & Clarke, 2006). After generating the sub-themes, the interpretations of the data were discussed and agreed upon by both researchers. Lastly, one researcher grouped the sub-themes together into themes, and extracted example quotes for each sub-theme. Going through the six phases of thematic analysis, the data was reduced from the audio recordings of the discussions to a framework of themes and sub-themes (Braun & Clarke, 2006).

3.3 Results

3.3.1 Participant characteristics

There were 42 individuals who took part in one of eight focus groups, or one of two individual interviews. There were between three to seven people in each focus group. Focus groups included one females only group, one group with only males, one group with only individuals who worked, three groups with only individuals who did not work, and two mixed groups. One focus group was conducted at the sheltered housing accommodation with five participants; one focus group was conducted at the residential home with four participants. The participants were 22 females and 20 males, aged 56 to 96 years, and years of education received ranged from 10 to 22. Fifteen participants lived alone, eight participants wore dentures and eight participants were classified as frail. Other participant characteristics can be found in table 3.1.

One elderly lady was excluded from the transcript after the focus group discussion was held because she was judged not cognitively able to make an informed decision to participate. Her taking part was due to a misunderstanding that she was selected by the staff members; while she had sat down with the group herself (the discussion took place in the common area of the residential home).

Table 3.1 Participant characteristics (N = 42) The values provided are number of responses and percentage of all responses in the specific category.

Characteristic		Value
Age in years		67 ± 9
Gender	Male	20 (48%)
	Female	22 (52%)
Working	Working (>20h)	11 (26%)
	Not working (or <20h)	31 (74%)
Frailty	Frail	8 (19%)
	Not frail	33 (79%)
BMI in kg/m^2 (Mean ±SD)		29 ± 5
Marital status	Married	21 (50%)
	Used to be married	14 (33%)
	Never married	6 (14%)
Living status	Alone	15 (36%)
	With others	26 (62%)
Education in years (Mean ±SD)		15 ± 3
Most recent employment level	Unemployed	0 (0%)
	Manual worker	5 (12%)
	Non-manual worker	11 (26%)
	Professional/Management	25 (60%)
Denture wearing	No dentures	34 (81%)
	Partial dentures	5 (12%)
	Full dentures	2 (5%)
Physical disabilities hindering food purchasing	No	32 (76%)
	Yes, some	6 (14%)
	Yes, a lot	2 (5%)
Physical disabilities hindering food preparing	No	33 (79%)
	Yes, some	7 (17%)
	Yes, a lot	1 (2%)
Physical disabilities hindering food consumption	No	35 (83%)
	Yes, some	6 (14%)
	Yes, a lot	0 (0%)

* For several variables the numbers do not add up to n=42 because one person did not fill out the questionnaire and one person left some questions open.

3.3.2 Reflexivity

Both researchers involved in analysis have background knowledge in eating behaviour and the determinants of food choice. They are familiar with literature about determinants of food choice in general, determinants specific to older adults, and specific to protein intake. This may have affected the follow up questions during

the focus group, identifying reasons and themes during the analyses, and defining the reasons and themes.

3.3.3 Reasons for eating or not eating eggs

Reasons for eating or not eating eggs, as well as reasons for eating or not eating the other protein rich foods were coded as sub-themes, but kept separate in the analyses. Most reasons came up for both food groups, there were a few reasons that were only discussed as reasons for eating or not eating non-egg protein rich foods, these are described below in section 3.3.4. The study is focused on the individual sub-themes more than the themes; the sub-themes will be referred to as 'reasons' in the rest of the report.

Table 3.2 Themes and reasons

Themes	Sub-themes /Reasons
1. Hedonics	Appeal, Liking
2. Properties of the food	Appearance, Complete, Flavour, Freshness, Moreish, Odour, Quality, Satiating effect, Size, Texture
3. Preparation style	Combination, Processing
4. Convenience	Convenience, Culinary skills, Effort to prepare, Planning, Practicalities, Time to prepare
5. Physical environment	Experience, Availability, Cost, Financial situation, Standby, Value for money
6. Variety	Replacing foods, Variety, Versatility, Wide variety of choice
7. Physical health/abilities	Appetite, Digestibility, Eating abilities, Genes, Medical factors, Physical abilities, Sensory abilities
8. Nutrition and health knowledge	Balanced diet, Health beliefs, Nutritional knowledge, Recommendations, Restraint, Sufficiency, Value
9. Food safety	Food safety, Food scares, Spoilage/ Wastage
10. Social environment	Culture, Other people present, Politeness
11. Morality	Animal welfare, Environmental issues, Food origins, Moral values
12. Emotion	Comfort, Masculinity, Status, Treat
13. Habit	Familiarity, Habit, Previous experience, Substantial meals, Staple food, Suitability, Trend, Trying new things, Upbringing

A total of 69 different reasons for eating or not eating eggs were identified. For the purposes of presentation, these reasons are grouped into 13 themes. Many reasons however, were closely related, and there is some overlap in the classification of reasons to themes. All reasons are described in a neutral manner, because the same factor might be a barrier or a facilitator for increasing egg intake for different people. Themes and reasons can be found in table 3.2, and appendix 3.2,

definitions and example quotes are described below. The definitions for all reasons can be found in appendix 3.3, quotes for each reason in appendix 3.4, and an overview of the number of references and sources of each reason can be found in appendix 3.5. FG is used for focus group, e.g. FG1 means focus group number 1.

The theme *hedonics* (theme 1) represents all references to liking or disliking egg (liking) or whether the idea of an egg preparation appealed to them or not, usually without having tried it (appeal). Examples of quotes can be found below.

"I like a nice fried egg" (FG 7)

"Pickled eggs, don't appeal to me at all. I can't say I've ever eaten them." (FG 3)

Several different *Properties of the food* (theme 2) came up in the discussions, this theme was used for all references to how an egg dish/preparation looks (appearance) and smells (odour), both illustrated in the quotes below; and for references to the taste (flavour), consistency (texture), size (size), quality (quality) of eggs/egg dishes. Lastly this theme includes any references to eggs being filling or not (satiating effect), and it being perceived as a meal in itself or a complete package (complete).

"I think eggs have an appearance going for them.." (FG 6)

"And I'm also conscious of the fact that if I open up my lunchbox in the office, and I got egg sandwiches, then that office is going to smell in an unpleasant sort of way." (FG 6)

All references to eating eggs in combination with other foods and/or as part of a dish (combination) or participants talking about whether they find it important to know how the eggs were prepared (processing) were put together under the theme *preparation style* (theme 3). Quotes to illustrate these reasons can be found below.

"You wouldn't have an egg with a gin and tonic, would you? Where you can have a hand full of nuts." (FG 4)

"And partly the reason why I always have eggs, is cause I like baking" (FG 2)

“I won’t go for the devilled egg, cause I don’t like sort of things where I don’t know what the other ingredients are apart from the egg.” (FG 4)

The theme *convenience* (theme 4) consists of any mentioning of whether storing, preparing or eating an egg/egg dish is easy or convenient (convenience), whether it takes much effort (effort to prepare), or time (time to prepare), or planning (planning), whether it is practical to prepare (practicalities), or whether the participants are able to cook it or not (culinary skills). Quotes assigned to the reasons convenience and time to prepare are listed below.

“I have them [eggs] because they are very convenient, they are very easy to prepare.” (FG 1)

“It’s very very good, if you, you come in, and you’re hungry. They’re very quick. That’s why I eat them mostly.” (FG 1)

The theme *physical environment* (theme 5), categorized all references to people’s physical surroundings in terms of the price of eggs as illustrated in the first quote below (cost), the value for money (value for money), and the influence of financial situation on choosing to eat eggs (financial situation). Additionally, it includes whether eggs are seen as a standby (standby), whether having eggs around influences intake (availability), in case of having them in the house like described in the second quote below, or eggs being served by others. This theme also includes quotes about eating eggs because it is a certain/special occasion, e.g. on holiday (experience).

Actually that is another thing that’s good about eggs. How cheap they are. You can make a meal cheaply with eggs.” (FG 1)

“My husband often cooks a tortilla, the Spanish omelette. And it sits in the fridge, and you can’t really open the door without having a piece.” (FG 3)

The theme *variety* (theme 6) includes all quotes about whether eggs are eaten to change the variety in the overall diet from a hedonic point of view (variety), about egg as an alternative for other foods (for example, like in the first quote below (replacing foods)), but also includes quotes like the second quote below referring to

whether eggs are considered versatile (versatility), and what people think about the variety of eggs available, e.g. in shops (wide variety of choice).

"I don't tend to eat them for breakfast cause I have cereals.." (FG 2)

"They're very versatile aren't they? You can use them in so many different ways." (FG 4)

When people referred to any problems or lack of problems with health in terms of eating eggs, it was assigned to the theme *physical health/abilities* (theme 7). This theme includes references to eating eggs being affected by taste or smell or any of the other senses (sensory abilities), the participants' abilities to bite, chew or swallow (eating abilities), or abilities in physical acitivity, e.g. reaching shelves in the supermarket (physical abilities). It also includes any quotes in terms of choosing eggs in relation to a medical condition (medical factors), in relation to digestion (digestibility), or (not) eating them because it is part of your ancestors' diet, or something that runs in the family (genes). Examples of quotes assigned to eating abilities, physical abilities, and sensory abilities are listed below.

"There's more to chew in meat than, that's where eggs and fish and that are much easier to eat." (FG 1)

"And they do repeatedly put them [eggs] on a high shelf. So you're frightened they're gonna break when you try to reach them." (FG 1)

"I mean I tried a boiled egg the other day and I just think your taste changes over the years." (FG 7)

The theme *nutrition and health knowledge* (theme 8) consists of references to eating or not eating eggs to balance out different foods as part of an overall diet from a health and knowledge point of view (balanced diet), because they are believed to be good or bad (or healthy like in the first quote below) (health beliefs), or beneficial in general (value), or because of their nutritional value (nutritional knowledge) as illustrated in the second quote below. It also includes reasons for eating or not eating eggs based on recommendations, advice or reports about nutrition and health (recommendations), or because people believe a certain

amount is enough without giving any other reason for it (sufficiency), or because they are actively avoiding certain foods (restraint).

"I wouldn't go for a fried egg, because I don't think that's healthy." (FG 4)

"..they're [eggs are] protein and that's fine, it's not a meat meal, but at least I've had some protein.." (FG 2)

Food safety (theme 9) as a theme includes any references to whether eggs are considered safe to eat (food safety), references to bacteria related food scares that are known by most of the general public (food scares), as well as references to eating eggs to prevent them (or other foods) from going off or having to throw them away (spoilage and wastage). Example quotes referring to food safety and spoilage and wastage can be found below.

"My eggs sit on the side, I don't keep 'em in the fridge and I never look at the dates, never have. And I've never been ill from an egg, so. It's never worried me" (FG 2)

"And I also had hard boiled eggs, about a week ago. Because I needed to use them up. Because they had got to their sell by date. So I hard boiled them." (FG 1)

Social environment (theme 10) was used for all quotes concerning cultural habits or traditions (culture), or for quotes like the example quotes below, concerning the social influence on eating eggs of other people in the family or possibly guests at an eating occasion (other people present), or eating eggs because you are being polite or avoiding being impolite (politeness).

"Well, I like any eggs, but me partner likes boiled eggs.." (FG 6)

"So I couldn't tell her that I didn't like it [omelette], cause I felt that wasn't the right thing to do." (FG 2)

The theme labelled *morality* (theme 11) is used for references to where the eggs come from (like the example below), e.g. free range eggs, cage eggs, or organic eggs (food origins), and quotes in relation to how the chickens are kept (animal welfare).

“I’d rather know where they came from rather than how cheap they are.” (FG 4)

The theme *emotion* (theme 12) combines all quotes where eggs are talked about as a comfort food (comfort), or something to treat yourself or others (treat), or a manly or feminine food (masculinity). It also includes quotes about the status eating or serving eggs gives you, e.g. whether eggs would be served at a dinner party (status). Example quotes can be found below.

“So I think there’s a lot of comfort in an egg, because I feel very guilty about eating things that I shouldn’t eat. And with an egg, I can eat it, so I have a lot of eggs.” (FG 5)

“An egg is dead easy, anybody can cook an egg. It doesn’t need a lot of education. Perhaps that’s the appeal to men, I don’t know.” (FG 6)

“I think if you’re having people round, eggs probably wouldn’t be a first choice.” (FG 4)

“..it’s like whether you want to try and impress or whether you just want to give somebody a healthy meal. Just something that you’d rather make an effort out of.” (FG 4)

Quotes fall under the theme *habit* (theme 13) if they were about habitual behaviour concerning eating eggs (habit), whether eggs were perceived to be familiar foods (familiarity), willingness to try new recipes or dishes with eggs (trying new things), or habitually buying eggs on a regular basis (staple food). This theme also includes references to eating or not eating eggs because of a prior experience (previous experience), references to eating eggs while growing up (upbringing), or eating behaviour in their surroundings while growing up, e.g. whether eggs were around a lot, or whether they were eaten a lot by other people (trend). Lastly, it includes any references to eggs being suitable to eat in a certain situation (suitability), or eggs being eaten as a snack food or a substantial meal (substantial meals). Example quotes for habit, substantial meals, and suitability can be found below.

“I start everyday normally with eggs.” (FG 3)

“It would be a snack food, egg, rather than a substantive meal.” (FG 2)

"Although if you have it the wrong time of day, if you had a boiled egg for tea for example whereas we normally have a proper meal then I would feel short changed. If you had it for breakfast or for lunch maybe, then that's ok." (FG 5)

3.3.4 Reasons for eating or not eating non-egg protein rich foods

Most reasons related to egg consumption were also mentioned in relation to the non-egg protein rich foods. There were, however, a few reasons derived from the discussions that were only used for talking about the other protein rich foods, and did not specifically refer to eggs. Because reasons in favour of another protein rich food might be a reason against eating eggs, it was decided to keep them in the framework and use them for future studies.

The reason labelled 'moreish' describes quotes about foods that are difficult to stop eating once you start eating them, e.g. nuts. This reason is included in the theme '*properties of the food*' because it is believed to be a characteristic specific to the food itself. 'Environmental issues' is the reason for references about the influence of certain foods on the environment, participants for example talked about the carbon footprint of foods being an important reason in their food choice. This reason falls under the theme *'morality*. The same theme includes the reason 'moral values', which is used to indicate when participants talked about any moral issues not covered by the other reasons, e.g. the influence of vegetarianism on global food security. The last reason that was not linked to eggs but might be important in this target age group was labelled 'appetite'. It refers to quotes about appetite changing with age, usually decreasing, and was included in the theme '*physical health/abilities'*.

3.4 Discussion

3.4.1 Reasons for eating or not eating eggs

The aim of this study was to investigate the reasons for eating or not eating eggs in older adults; 69 different reasons were identified and grouped into 13 themes. Previous studies report many of the themes as determinants of food consumption in the elderly population (Appleton, McGill, Neville, & Woodside, 2010; Falk et al.,

1996; Locher et al., 2009; Steptoe et al., 1995). Hedonic reasons, properties of the food, convenience, physical environment (including cost and value for money), physical health and abilities have been described as important determinants of food choice in older adults, while morality, emotion, nutrition and health knowledge, social environment, and habits are also reported (Locher et al., 2009). Some reasons, such as the properties of the food and physical health and abilities, have also been described before in relation specifically to the intake of protein rich foods in the elderly (Appleton, 2016; Best & Appleton, 2013; Rousset & Jolivet, 2002), and some reasons have been reported specifically in relation to the intake of eggs in younger adults (Fearne & Lavelle, 1996a, 1996b; Hernandez, 2006). When comparing determinants in younger and older adults, Steptoe et al. found that ethical concern (morality), familiarity (habit) and natural content were positively correlated to the participants' age, while convenience and physical environment are not specific to older age (Steptoe et al., 1995).

Themes that were specific to eggs and older adults include the properties of the food (e.g. texture and flavour) and convenience (e.g. culinary skills, effort and time to prepare) combined with physical health/abilities (e.g. eating abilities, sensory abilities, and physical abilities). Sensory analyses with older adults have previously shown that eggs were popular for their soft texture, while different types of meat were characterized to have more difficult textures (tough, dry and/or stringy) (Rousset & Jolivet, 2002). Studies indicate that older adults generally avoid hard and/or fibrous foods that can be difficult to bite or chew including meat and nuts (Fucile et al., 1998). Older adults with difficulties specifically with chewing also report avoiding chewy/stringy foods like meat (Hildebrandt et al., 1997), and having a lower intake of beans and nuts (Kimura et al., 2013), meat and meat dishes, and total protein intake (Holmes & Roberts, 2011; Holmes et al., 2008). Older people with impaired dental status and chewing difficulties also consumed softer foods more often (including chicken, fish, grains, and dairy products) (Kossioni & Bellou, 2011). Moreover, for foods that are difficult to chew like meat, the chewing ability of older adults (Rémond et al., 2007) as well as the processing method (minced beef vs beef steak) (Pennings et al., 2013) can affect the postprandial digestion and absorption rates of the protein, meaning that even when people do eat meat they may not benefit optimally from the protein provided.

Cooking style can impact heavily on the sensory properties of the food (Bejerholm & Aaslyng, 2004; Roininen, Fillion, Kilcast, & Lähteenmäki, 2003). Many protein-rich

foods require cooking, and there may be some indications that lower cooking abilities and skills may be related to lower protein intake (Hughes et al., 2004), and specifically meat consumption (Hartmann, Dohle, & Siegrist, 2013). One study showed that Greek older people did not eat significantly less meat but overcame chewing difficulties by preparing difficult to eat foods in a different way (Kossioni & Bellou, 2011). Next to culinary skills, physical abilities affect the ability to cook, e.g. being able to stand for long enough to prepare a meal, and have the functional ability to prepare different foods. Previous work shows that significantly fewer women with rheumatoid arthritis cook their own meals compared to other women without or with milder rheumatoid arthritis (Allaire et al., 1991). For eggs, preparation style will have a strong influence on texture and ease or difficulty of consumption (e.g. scotch eggs might be more difficult, while most other preparations are soft and easy to bite, chew and swallow). Eggs are also notably much easier to prepare than many other protein-rich foods (Lewis & Bashin, 1988), and ease of preparation in terms of effort and time as well as skills and abilities was specifically mentioned by some of the participants, e.g. *"It's very very good, if you, you come in and you're hungry. They're very quick, that's why I eat them mostly." (FG1).* Additionally, different preparation styles and/or seasoning may affect the ability to taste or smell the dish. Studies have shown that adding sauces or seasonings can increase protein intake within a meal (Appleton, 2009, 2017b; Best & Appleton, 2011), and this could make a meal easier to eat and/or more appealing, but adding seasoning and preparing sauces can require a certain level of physical ability and cooking skills.

Reasons for eating / not eating eggs that may be specific to this particular older age group also include perceived medical factors like the cholesterol content of eggs, and to concerns over food safety. It has been suggested that the misconception that eggs are harmful for blood cholesterol, and can increase risk of coronary heart diseases (CHD), persists in the minds of many people (Gray & Griffin, 2009). From the 1960s, research studies suggested that cholesterol in foods was associated with increased risk of CHD, and therefore should be limited (Stamler & Shekelle, 1988). Eggs are one of the highest sources of dietary cholesterol in our diets, so recommendation were given to restrict their consumption to three to four per week (British-Heart-Foundation, 2015; Lee & Griffin, 2006). Even though recommendations were changed in 2007 to remove all restrictions, the custom of restricting egg intake might still be strong in people older than 55 years old who were recommended to do this for most of their lives. Similarly in relation to food

safety and food scares, one of the biggest UK salmonella food scares was in the late 1980s when Junior Health Minister Edwina Curry commented publicly on a high risk of salmonella food poisoning from British eggs. Although the risk of salmonella in UK eggs is now considered low or very low (Coia et al., 2016), at that time, the participants were adults at an age where they may have been preparing meals and adhering to Government advice.

Several reasons also emerged that relate specifically to eggs, and may be more influential in the older age group than in those younger. The theme morality includes issues of food origin and animal welfare, and the participants seemed very aware of topical societal concerns like the carbon footprint of different foods. Eggs have a relatively low greenhouse gas emission (GHGE), and could offer a protein rich alternative to meat and fish which have a larger GHG footprint (Eshel, Shepon, Makov, & Milo, 2014). Previous research also suggests ethical concerns in elderly people, although study results can be mixed (Locher et al., 2009; Steptoe et al., 1995), and it has been suggested that younger and older adults do not show differences in types of eggs consumed (Bejaei et al., 2011). This possibly differs between cultures, generations, education levels and personal interests, and depends on the participant sample. The theme labelled emotion includes 'status'. Many participants were positive about eggs, but they seem to consider eggs a food you would eat on your own or maybe with your family; several participants mentioned that they would not serve eggs when they have people over for a dinner party. When asked why, the participants mentioned: "*..it's like whether you want to try and impress or whether you just want to give somebody a healthy meal. Just something that you'd rather make an effort out of." (FG 4).* It might be that this generation thinks of eggs as an everyday type of food that is not suitable to serve to others. Eggs have previously been reported as a food more commonly consumed in households with lower incomes (Appleton et al., 2007; Fearne & Lavelle, 1996b). A reason that is not often reported in other studies was 'masculinity'. The impact of gender specific consumption stereotypes on food choice can result in unhealthy eating habits (Vartanian, Herman, & Polivy, 2007), and might not be easily changed (Johnston & Macrae, 1994).

Lastly, many participants did not feel they needed to increase their egg intake because they felt that they already eat enough eggs (see 'sufficiency'). Previous research into protein enriched foods has shown that the elderly report being willing to increase protein intake if they have a protein deficiency and/or a family doctor

advises them to eat it (van der Zanden et al., 2014a). It became evident that the participants in this study differed a lot in whether and the means by which they would be willing to increase egg intake. Many of the older adults in this study also had strong ideas about what they felt would be a suitable way to eat eggs (see 'suitability'), which might indicate it could be important to personalize recommendations, or interventions to be easily applicable in different lifestyles and preferences.

3.4.2 Strengths and limitations

The reasons are described in a neutral manner, and not classified as a barrier or facilitator to egg consumption because the same factor might be a barrier or a facilitator for increasing egg intake for different people. The aim of the study was not to assess individual differences in how these reasons affect egg intake, or which reasons are more important than others in predicting egg intake in different people. The sample size is too small to draw such conclusions based on this study.

Due to the nature of this study the research outcomes are contextual; the conclusions are based on the ideas and experiences of 42 participants who live in or close to Bournemouth (UK). The outcome topics are, however, believed to be transferable to other samples of participants in the target age group, and therefore theoretically generalizable to a larger sample.

When interpreting the results it should be taken into account that the procedure of the focus groups and interviews may have prompted the participants. By showing pictures of different types of egg preparations this may have prompted the participants to talk about variety and versatility.

A strength of the study is that the participants were recruited to include different subgroups within the target age group, for example, people of different ages and genders, people who work or do not work, and are classified as frail or not. This study combined the use of focus groups and individual interviews to gain a more comprehensive understanding of the data (Lambert & Loiselle, 2008). It was believed people might discuss different reasons, or the same reasons more in depth, when in a group or alone. Focus groups are especially likely to prompt group interaction, and subsequently focus on the group's attitudes, understanding, language, and the group norms (Kitzinger, 1994). Because the target age group is

heterogeneous in lifestyle, physical abilities and eating behaviour, the participants were recruited to be representative of different types of older adults. In the data analyses, individuals or subgroups were not compared, they were included only to potentially find more reasons or have the reasons be discussed in more detail.

3.5 Conclusions

To conclude, this study identifies many reasons for eating or not eating eggs in a sample of British adults over the age of 55 years. Many of these reasons also relate to food intake in general, or to other protein-rich foods, but some reasons may be specific to eggs and the older population.

The wide range of different reasons for egg consumption identified in this study presented the opportunity for further examination using quantitative methods. The following chapter (chapter 4) describes how the relative importance of the reasons in relation to habitual egg intake was assessed in a large national sample. Identification of those reasons of direct impact on egg consumption could help in designing specific strategies to increase egg intake and towards a food based approach to improve or maintain protein status in the UK older population.

4. Exploring the consumption of eggs in older adults: a questionnaire study

4.1 Introduction

The literature review in chapter 2 of this thesis outlines that low dietary protein intake has an important impact on adverse health outcomes likely to affect the elderly (Bauer et al., 2013; Deutz et al., 2014; Volpi et al., 2013), while physiological, psychological and social factors specific to ageing can affect dietary intake and specifically protein intake (Appleton, 2016; Best & Appleton, 2013; Donini et al., 2003; Nieuwenhuizen et al., 2010). The previous chapters also describe how increasing egg consumption may be a helpful dietary strategy to increase protein intake, but in order to design an intervention to increase egg intake in older adults, a thorough understanding of egg consumption in the target age population is crucial.

Chapter 3 described how a qualitative study was designed to find as many reasons for eating or not eating eggs as possible using focus groups. An overview of the 69 reasons that were identified can be found in appendix 3.2. This chapter reports how the outcomes of the focus group study were used to design a structured questionnaire study.

This cross-sectional study aimed to investigate the relative importance of the reasons for eating or not eating eggs identified in the focus group study in predicting the habitual consumption of eggs in a National sample of British adults over 55 years old. Additionally, the influence of demographic characteristics and lifestyle factors on habitual egg intake was assessed.

4.2 Methods

4.2.1 Questionnaire

Egg and protein intake frequency

The questionnaire can be found in appendix 4.1. The questionnaire contained a food frequency questionnaire to measure habitual egg intake, listing 18 different types of egg preparations, including: boiled eggs (hot), hard boiled eggs (cold), fried

eggs, scrambled eggs, poached eggs, omelettes, scotch eggs, quiches/savoury flans, egg mayonnaise, egg sandwiches, egg salad, custards, meringues, sweet flan/crème caramel, duck/quail's eggs, raw eggs, egg yolk separate from the white, and egg white separate from the yolk. Participants were asked to report frequency of consumption a seven point scale including: 'more than once a day', 'more or less daily', '3-5 days a week', '1-2 days a week', '1-3 days a month', 'less than monthly', and 'never'. The same frequency measures were used to assess the participants' habitual intake of a list of 18 different types of protein rich foods, including: white meat (e.g. chicken, turkey); red meat (e.g. beef, lamb, pork); processed meat (e.g. ham, bacon, sausages, corned beef); white fish (e.g. cod, haddock); oily fish (e.g. sardines, salmon); seafood (e.g. prawns, mussels, crab); vegetarian meat substitute (e.g. Quorn); milk (excluding milk in tea/coffee); milk in coffee or tea; yoghurt, custards, blancmanges, etc.; hard cheeses (e.g. Cheddar, Stilton); soft cheeses (e.g. cream cheese, brie, cottage cheese); nuts and seeds; pulses (e.g. lentils, Dahl); beans or peas; bread (e.g. white or whole meal); and breakfast cereals or porridge. The foods were selected based on other studies (Appleton, 2016) and the sources of protein contributing most to protein intake in elderly in the national diet and nutrition survey (NDNS) data (Bates et al., 2014). For all the foods, participants were also asked to indicate when in the day they would normally eat this type of egg, with answer options: 'breakfast', 'lunch', 'evening meal', 'snack'. This was asked to get an indication of when people eat eggs, and the different protein rich foods. Dose and distribution of protein per meal is known to be important for optimal muscle protein synthesis in older adults (Murphy et al., 2016).

Reasons for eating or not eating eggs

The questionnaire included at least one statement for each reason identified in the focus group study. A total of 76 statements about eggs were presented with a five point Likert scale representing the answer options 'strongly disagree', 'disagree', 'neither disagree nor agree', 'agree', and 'strongly agree'. The statements were based on the 69 reasons identified in the focus group study, seven reasons were allocated several statements because they referred to a combination of slightly different topics, or for face validity reasons. For example, the reason 'Recommendations' was represented with three statements: recommendations from the media, recommendations from friends and family, and recommendations from health professionals. People may perceive these different recommendations in a different way, and the focus group quotes assigned to this reason included all three different types. Dividing some reasons into different statements is believed to

benefit the face validity and clarity of the questionnaire. For all statements in the questionnaire, special attention was paid to the wording of questions, looking into the focus group transcripts for language use of the target population.

An additional 19 statements with the same Likert scale were included for the reasons appearance, flavour, moreish, odour, satiating effect, texture, combination, processing, convenience, culinary skills, effort to prepare, planning, practicalities, time to prepare, comfort, masculinity, femininity, and status-guests. For each reason the general statements were repeated while replacing the word ‘eggs’ with ‘my favourite type of egg’. This was done with the idea that for some statements a person’s response can depend on the type of egg preparation they have in mind. To standardize this without knowing which preparations are liked or disliked, the participants were instructed to write down their favourite type of egg preparation and think about this type while responding to the statements that followed.

Demographic characteristics and lifestyle factors

The questionnaire also included questions on lifestyle factors. Difficulties with everyday activities were measured using an adapted version of a questionnaire to diagnose sarcopenia (Malmstrom & Morley, 2013), to give an indication of whether the participants were frail or sarcopenic. Other questions included were specifically asking about whether people receive help with food shopping or preparation, eat out or away from home, or whether they get food delivered, because this is another indication of the participant’s physical abilities and possible solutions to overcome them. Additionally, a question about whether the participants wear dentures was included, because dental status is known to affect food intake in the elderly (Millwood & Heath, 2000), and a validated ten item questionnaire to measure ‘food neophobia’ was included (Pliner & Hobden, 1992), as a measure of willingness to try new foods. Lastly, additional questions were focused on demographic information, including: age group, gender, height and weight (which was converted to Body Mass Index (BMI)), marital status, living status, (first half of) postcode, education level (total number of years), nationality, and most recent level of employment. Age, gender and postcode were included to be able to check whether the responses were representable compared to the census 2011, and/or to see if they influenced egg intake. Other demographic characteristics were included to assess how they relate to egg intake. Two questions were included on whether participants had allergies to eggs, or had any conditions that had changed their

eating behaviour (e.g. chemo-/radio therapy) in the last 6 months, which are both exclusion criteria in this study.

Pilot study

A pilot study was performed to test the questionnaire for face validity, and internal reliability using a similar target age group as for the main study, including 15 individuals from the local population. Question statements and formatting were refined during and following piloting to increase clarity. None of the statements were taken out completely, for 12 statements the wording was changed, and one statement was added to increase face validity. This specific statement was about femininity, while the pilot questionnaire only included a statement about masculinity.

4.2.2 Questionnaire administration

The questionnaire was sent out to a national sample of 1000 community dwelling older adults (over 55 years old). The sample was representative of the number of males and females per five year age group living in each different area of the UK, as reported in the Census 2011 (Office-for-National-Statistics, 2011). The sample of names and addresses (with additional demographic information available) was obtained from the data sampling company 'Sample answers' (Sample-answers, 2016). All individuals in the data base have previously filled in a survey and said they would be willing to be contacted for other surveys. They did not consent to this specific study. Everyone in the obtained sample was sent a questionnaire through the post. An additional 82 questionnaires were sent out to a national sample of people aged over 55 years old who had been in contacted about previous studies and indicated that they would be willing to be contacted for other research studies.

There was an online and a paper version of the same questionnaire. The paper version of the survey was sent out to all the addresses acquired, and included a sticker with the 'free post' return address. The link to the online survey was printed on the paper questionnaire in case people preferred to fill it out online. A total of 588 participants were pre-notified by telephone, with a brief conversation or voicemail message announcing that a questionnaire would arrive at their address soon. Reminders were sent out to non-responders about 6 weeks, and 6 months after posting the first questionnaire. Additionally, participants could choose to be entered in a random draw of supermarket vouchers, or request to be sent the results of the

study. Ethical approval for this study was granted by the Research Ethics Committee of Bournemouth University.

4.2.3 Data analyses

First, people with allergies to eggs, and people who had had conditions that had changed their eating behaviour (e.g. chemo-/radio therapy) in the last 6 months were excluded from the data analyses. Then the data were screened for missing values. If responses for the main variables (statements about eggs and the habitual egg intake measure) were missing by more than 20% for a particular participant, this individual's data were excluded from the data analyses. If 80% or more were completed, missing values were imputed. The value for 'neither disagree nor agree' was entered for statements left open, or in case two boxes were ticked for one statement, the average score was used. Demographic information was examined using χ^2 tests to check if the sample included in the analyses was representative of the British population over 55 year old according to the Census 2011 (Office-for-National-Statistics, 2011).

Data analyses were performed using IBM SPSS Statistics software (version 22.0). Including all 76 statements individually in the regression would reduce the power of the analyses (Howell, 2012). To reduce the number of variables to analyse in the regression model, the statements were grouped using a Principal Component Analysis (PCA). An orthogonal rotation with a varimax method was chosen because the components should remain independent (uncorrelated) of each other, and to increase the interpretability of the components. The component loadings generated in the analysis were used together with semantic reasoning to classify the items into a smaller set of components. By using a method of grouping the items based on statistical analyses of the participant responses rather than the themes created in the thematic analysis following the focus groups, the potential bias in interpretation of the reasons by the experimenter was reduced. The components were then checked for internal reliability, by generating a Cronbach's alpha for all the items in each component. For all components with a Cronbach's alpha higher than .5 (Field, 2013), a component score was generated by adding up the individual scores for all items in each component. These component scores were then included in a Multiple Linear Regression analysis as possible predictors of egg intake. The food intake frequency data were converted to one number representing number of eggs eaten per month, and to number of protein rich foods eaten per month, and added into the

analyses as a lifestyle factor. The category ‘more than once a day’ was counted as 60 times eaten per month, ‘more or less daily’ as 30 times, ‘3-5 days a week’ as 16 times, ‘1-2 days a week’ as 6 times, ‘1-3 days a month’ as 2 times, ‘less than monthly’ as 0.5 times, and ‘never’ as 0 times per month. Most foods were counted as equal “units” or portions, with a few exceptions. Milk in coffee or tea, which was counted as 0.2 portion for each time consumed. For the egg dishes custards, meringues, and sweet flan/ crème caramel each time consumed was counted as 0.5 portion, because a standard portion tends to be less than one egg while for the others it would be one egg or more. For all other foods, differences in protein content, or number of eggs, were not taken into account. The frequency of consuming high protein foods is measured, not the amount of protein consumed.

Multiple linear regressions were conducted to assess whether the demographic characteristics and lifestyle factors, or the PCA components predict egg intake. For a multiple linear regression a general rule of thumb is that a minimum of 50 plus eight participants for each predictor variable included is needed (Green, 1991). The sample was therefore too small to enter all demographic characteristics and life style factors and the 20 PCA components. To assess whether the demographics characteristics and lifestyle factors predict egg intake, they were entered in a separate multiple linear regression model. Variables predicting egg intake significantly were then added to the regression model with the PCA components as possible predictors of egg intake. Before running the regression model the missing values for those significant predictor variables were filled using mean imputation, in order to maintain the sample size. For analysing the statements about ‘favourite type of egg’, the intake data for only the egg type which was listed as favourite was used as the outcome variable for a regression analysis. A multiple linear regression model was run to see whether the specific statements about ‘favourite type of egg’ would predict the intake of the participant’s specified favourite type of egg. The statements about favourite type of eggs were combined with other favourite egg specific statements of the same PCA component if applicable; otherwise they were entered as predicting variables on their own. Lastly the responses on what time of day the eggs and other protein rich foods were eaten were presented in frequencies, to give insight into the time of day people eat eggs and specific types of egg preparations.

4.3 Results

4.3.1 Participant characteristics

A total of 259 individuals returned the questionnaire (24% response rate, or 26% when taking into account 87 questionnaires returned due to wrong addresses). Of these, 26 were excluded based on the exclusion criteria and the number of missing values in the main variables. For the regression three more participants were excluded, because their egg intake values were more than three standard deviations from the mean egg intake value, and therefore classified as outliers. Although extreme values can be interesting, outliers were excluded for the final data analysis because they might skew the data. The responses of a few participants with very high egg intake values could have affected the outcomes of the regression analyses, and were therefore excluded. Demographic information about the 230 remaining participants can be found in table 4.1, and appendix 4.2.

Table 4.1 Participant characteristics (N = 230)

Characteristic	Value
Age*	
55-59 years old	32 (13.8%)
60-64 years old	38 (16.4%)
65-69 years old	54 (23.3%)
70-74 years old	48 (20.7%)
75-79 years old	36 (15.5%)
80+ years old	22 (9.5%)
Gender*	
Male	119 (51.3%)
Female	110 (47.4%)
BMI in kg/m^2 (Mean $\pm$SD)	27 $\pm$ 5
Egg intake in frequency per month (Mean $\pm$SD)	18 $\pm$ 13
Protein intake in frequency per month (Mean $\pm$SD)	155 $\pm$ 61
Marital status*	
Married	149 (64.2%)
Divorced	28 (12.1%)
Widowed	33 (14.2%)
Never married	17 (7.3%)
Living status*	
Alone	66 (28.4%)
With others	161 (69.4%)
Education in years (Mean $\pm$SD)	13 $\pm$ 2
Most recent employment level*	
Unemployed	11 (4.7%)
Manual worker	44 (19.0%)
Non-manual worker	86 (37.1%)
Professional/Management	86 (37.1%)
Denture wearing*	
No	156 (67.2%)
Partial dentures	55 (23.7%)
Full dentures	17 (7.3%)

* The values provided are number of responses and percentage of all responses in the specific category. For several variables the numbers do not add up to n=230 because different people left different questions open. They were not excluded because the power would get too low.

Age, gender and region of residence of all respondents included in the analyses were investigated using χ^2 tests to ensure the sample was representative. Unfortunately the sample was not representative for all categories. There were several significant differences between the numbers of respondents in a certain category and the number of expected respondents based on the Census. For age (χ^2 (6) = 37.36, $p < .01$), only the age group 60-64 years old was not significantly different. The 55-59 year old group and 80+ group were under represented, while the 65-69 year old, 70-74 year old, and 75-79 year old groups were over represented. For gender there were no significant differences between the observed and expected respondent numbers. For region the overall responses were significantly different (χ^2 (12) = 60.15, $p <.01$), responses from Scotland were under represented, and respondents from the South West were over-represented. The results can be found in appendix 4.3.

4.3.2 Generating components

The principal component analysis on the 76 statements about eggs was based on the responses of 182 participants, because this was the sample size when first analyses were conducted. More responses were collected afterwards to run the final data analyses, but the components from the initial principal component analysis were kept for further analyses. The principal component analyses resulted in 23 components explaining 69.9% of the variance. Using the component loadings and semantic reasoning, all items were assigned to one of these 23 components. After this the reliability of the components was assessed using Cronbach's alpha, based on the initial 182 responses. Three components had a Cronbach's alpha value that was under .5, therefore, these three components were excluded from the regression. The resulting 20 components were titled: liking/flavour/variety, value for money, food chain, everyday food, effort, previous experience, past, occasion, stereotypes, sensory, expectations, willingness to eat more eggs, external reports, eating less with aging, medical factors, moreish, suitability, familiarity, size, and food safety. Preliminary analyses were conducted when 203 surveys had been received, and 21 were excluded based on missing values, leaving a sample of 182. The PCA was based on this sample. When additional responses were added to the total sample and the data re-analysed, the initial components were kept. The combinations of reasons into components as a result of the PCA were used to generate component scores for the new total data sample. The components in the

final sample showed no multicollinearity, with no correlation scores higher than r > .7. With the final sample of responses (N=230), new Cronbach's alpha values were generated, some of the values that were above .5 for the initial sample, were now below .5. For ten components the Cronbach's alpha decreased. For two of those components the Cronbach's alpha values decreased to be below .5, while they were above .5 for the initial sample. The classification of subthemes/reasons into components, with the final Cronbach's alpha values and questionnaire statements, is shown in table 4.2 and definitions can be found in appendix 4.4.

Table 4.2. Overview of the components generated using the Principal Component Analysis (PCA). Per component the reasons are given with their accompanying statements from the questionnaire. Reasons marked with (R) were reverse scored in the analyses because their component loadings in the PCA were negative.

Component	Included variables	Statements
1. Liking, flavour, variety (α = .795)	- Variety	- Eggs add variety to my diet.
	- Balanced diet	- I think eggs are part of a balanced diet.
	- Flavour	- I think eggs taste good.
	- Liking	- I like eggs.
2. Value for money (α = .715)	- Spoilage/wastage (R)	- *I think eggs go off quickly.*
	- Versatility	- I think eggs are very versatile.
	- Standby	- I think eggs are a good standby.
	- Cost	- I think eggs are cheap.
	- Value	- I think eggs are nutritious.
	- Planning	- Preparing eggs does not need a lot of planning for me.
	- Complete	- I think eggs are like a compact little parcel.
	- Substantial meal	- I think eggs are a good snack food.
	- Value for money	- I think eggs are good value for money.
	- Financial situation (R)	- *I eat eggs often because my income is not very high.*
	- Nutritional knowledge	- I know why eggs can be good or bad for health.
3. Food chain (α = .767)	- Processing	- It's important to me to know how my eggs are prepared.
	- Freshness	- It is important to me that the eggs that I eat are fresh.
	- Animal welfare	- It is important to me that eggs are free range.
	- Wide variety of choice	- The range of eggs where I shop is good.
	- Quality	- The quality of the eggs that I eat is important to me.
	- Food origin	- It is important to me to know where eggs come from.
4. Everyday food (α = .686)	- Convenience	- Eggs are convenient for me.
	- Satiating effect	- I think eggs are filling.
	- Habit (R)	- *Eating eggs is not part of my routine.*
	- Staple food	- Eggs are a staple food for me.
	- Recommendations - friends/family	- I eat eggs regardless of what my friends and family recommend.
	- Digestibility	- Eggs are easy for me to digest.
5. Effort (α = .700)	- Practicalities	- Preparing eggs is not practical.
	- Effort to prepare	- Eggs take a lot of effort for me to prepare.
	- Politeness	- I eat eggs out of politeness.
	- Health beliefs	- I think eggs are unhealthy
	- Culinary skills	- I can cook eggs.
	- Eating abilities	- I find eggs difficult to chew and swallow.
	- Availability - served by others	- I only eat eggs when they are served to me and I do not have to prepare them myself.

6. Previous experience (α = .524)	-	Genes	-	I have a family history of problems after eating eggs.
	-	Previous experience	-	I have had bad experiences with eggs in the past.
	-	Medical factors - general	-	I do not eat eggs because of a medical condition.
7. Past (α = .595)	-	Trend – availability	-	There were not many eggs around when I was younger.
	-	Trend - popular (R)	-	*Many people used to eat eggs when I was younger.*
	-	Upbringing	-	I was not brought up eating eggs.
8. Occasion (α = .521)	-	Comfort	-	Eggs are a comfort food for me.
	-	Experience	-	I eat eggs when it is a particular occasion, e.g. on holiday.
9. Stereotypes (α = .565)	-	Masculinity	-	I think eating eggs is manly.
	-	Environmental issues	-	I think egg consumption is bad for the environment.
	-	Status personal	-	I think eating eggs is beneath me.
	-	Masculinity fem	-	I think eating eggs is feminine.
10. Sensory (α = .611)	-	Odour	-	I think eggs smell nice.
	-	Appearance	-	I think eggs look nice when they are ready to eat.
	-	Texture	-	I think eggs have a nice consistency.
11. Expectations (α = .544)	-	Combination	-	I never eat eggs with other foods.
	-	Status guests	-	I would not serve eggs at a dinner party.
	-	Appeal	-	Eggs do not appeal to me.
12. Willingness to eat more eggs (α = .485)	-	Sufficiency	-	I would consider eating more eggs than I do currently.
	-	Replacing foods	-	I would consider replacing other foods in my diet with eggs.
13. External reports (α = .483)	-	Recommendations - media	-	I take recommendations about eating eggs from newspapers and the radio very seriously.
	-	Food scares (R)	-	*I eat eggs regardless of media reports about salmonella.*
	-	Recommendations - health professionals (R)	-	*I eat eggs regardless of what health professionals recommend*.
14. Eating less with aging (α = .516)	-	Appetite (R)	-	*I am still able to eat as many eggs as when I was younger.*
	-	Sensory abilities	-	Eggs have begun to taste different to me as I have got older.
	-	Restraint	-	I try to limit the number of eggs I eat.
	-	Physical abilities shopping	-	I have physical disabilities that hinder me from shopping for eggs (eg reaching shelves).
	-	Physical abilities preparing (R)	-	*I have no physical disabilities that hinder me from preparing eggs.*
15. Medical factors (α = .564)	-	Medical factors cholesterol	-	I limit the amount of eggs I eat because of the cholesterol.
	-	Medical factors heart disease	-	I think eggs increase the risk of heart diseases.
16. Moreish (PCA loading = .703)	-	Moreish	-	When I start eating eggs, I never want to stop.
17. Suitability (PCA loading = .744)	-	Suitability	-	In my opinion there are certain meals or situations where eating eggs is more appropriate than in other situations.
18. Familiarity (PCA loading = .796)	-	Familiarity	-	There are some egg dishes I have heard of but have never tried.
19. Size (PCA loading = .764)	-	Size	-	The size of the eggs I use does not matter to me (Small/Medium/Large).
20. Food Safety (PCA loading = .749)	-	Food safety	-	I only eat eggs when they are properly cooked.

*As many reasons as possible were included in the one of the components. Reasons that were not included in the final components, because they did not load on the components in the PCA or they made the Cronbach's alpha of the component decrease too much, were: 'culture', 'other people present', 'moreal values', 'treat', 'trying new things', 'time to prepare', 'availability – around'.

Table 4.3 Minimum, maximum, mean and SD for participants responses (n=230) for each component. Component scores are converted to scores ranging 1-5.

	Minimum	Maximum	Mean	*SD*
Liking/Flavour/Variety	1.00	5.00	4.03	0.55
Value for money	2.55	5.00	3.89	0.37
Food chain	2.17	5.00	3.70	0.60
Everyday food	1.00	5.00	3.54	0.58
Effort	1.00	4.00	2.13	0.45
Previous experience	1.00	3.67	1.68	0.57
Past	1.00	4.33	2.20	0.80
Occasion	1.00	5.00	2.28	0.81
Stereotypes	1.00	4.00	1.93	0.55
Expectations	1.00	5.00	2.17	0.70
Willingness to eat more eggs	1.00	4.50	2.72	0.72
External reports	1.00	4.67	2.37	0.68
Moreish	1.00	5.00	1.98	0.89
Medical factors	1.00	4.50	2.68	0.80
Suitability	1.00	5.00	3.31	0.92
Familiarity	1.00	5.00	3.69	0.74
Size	1.00	5.00	3.22	1.10
Food safety	1.00	5.00	3.76	0.91
Sensory	1.67	5.00	3.32	0.57
Eating less with aging	1.00	4.00	2.23	0.55

4.3.3 The influence of demographic characteristics and lifestyle factors on egg intake

The demographic characteristics and lifestyle factors did not show multicollinearity, with correlation scores lower than 0.7, tolerance scores greater than 0.1, and VIF scored all under 10 (Field, 2013). The multiple linear regression model including all demographic characteristics and lifestyle factors significantly predicted egg intake, with $R = .418$, $R^2 = .175$, adjusted $R^2 = .107$, $F(16, 195) = 2.584$, and $p = .001$. Looking at the predictors, protein intake was a significant predictor of egg intake (*Beta* = .311, $p < .001$), BMI was a significant predictor of egg intake (*Beta* = .166, $p < .05$), and duration of full time education significantly predicted egg intake (*Beta* = -.158, $p < .05$). All Beta values and p values can be found in table 4.4 and appendix 4.5.

Table 4.4 Outcomes of the multiple linear regression model assessing the effect of demographic characteristics and lifestyle factors on egg intake. Significant effects are given in bold (p<.05)

	Beta	*p* value
Protein intake frequency per month	**.311**	**.000**
Physical ability score	.088	.352
Food neophobia score	-.089	.204
Receiving help with food shopping	-.043	.670
Receiving help with food preparing	-.111	.169
Eating out or away from home	.028	.677
Getting food delivered	.047	.505
Age group	-.140	.066
Gender	-.082	.234
BMI	**.166**	**.017**
Region code	-.053	.443
Marital status	.034	.711
Living status	-.086	.372
Years of education	**-.158**	**.037**
Employment level	.034	.644
Denture wearing	.129	.079

4.3.4 The influence of the PCA components on egg intake

Using a multiple linear regression model with the 20 components, and protein intake and BMI, and years of full time education as independent variables and egg intake as the outcome variable, the components significantly predicted egg consumption in this sample (R = .563, R^2 = .317, adjusted R^2 = .240, $F(23,206) = 4.148$, $p < .001$). There were nine variables that significantly predict egg intake: liking/flavour/variety (*Beta* = .224, $p < .05$), value for money (*Beta* = -.182, $p < .05$), everyday food (*Beta* = .204, $p < .05$), stereotypes (*Beta* = -.151, $p < .05$), willingness to eat more eggs (*Beta* = -.141, $p < .05$), moreish (*Beta* = .194, $p < .01$), eating less with aging (*Beta* = .213, $p < .01$), protein intake frequency (*Beta* = .237, $p < .001$), and BMI (*Beta* = .172, $p < .01$). All Beta values as well as p values can be found in table 4.5, and appendix 4.6. Greater egg consumption was related to: greater liking and/or greater agreement that eggs are tasty, and add variety to the diet; less agreement that eggs are good value for money; higher agreement that eggs are an everyday type of food; less firm adherence to stereotypes about the type of person who eats eggs; lower willingness to increase egg intake (or greater agreement that sufficient quantities of eggs are consumed); greater difficulty stopping eating eggs once started; greater agreement to be eating less with aging; and was greater in people with higher protein intakes, and a higher BMI. For the statements of each component please see table 4.2. In appendix 4.6 more information about the regression analyses can be found, the table shows that the variance inflation factor (VIF) values are well below 10, the tolerance statistics are above 0.1, and therefore indicate that the components do not show multicollinearity (Field, 2013).

Value for money – Exploratory analysis

For the component 'Value for money' a separate linear regression was run for just the component value for money predicting egg intake. The model did not predict egg intake significantly, R = .074, R^2 = .005, adjusted R^2 = .001, F(1, 228) = 1.244, and p = .266.

Table 4.5 Outcomes of the multiple linear regression model assessing the effect of the PCA components, and protein intake, BMI, and years of education on egg intake. BMI and years of education were imputed with the mean. Significant effects are given in bold (p<.05)

	Beta	*p* value
Liking/Flavour/Variety	**.224**	**.018**
Value for money	**-.182**	**.025**
Food chain	.065	.341
Everyday food	**.204**	**.012**
Effort	-.122	.143
Previous experience	.104	.158
Past	-.018	.787
Occasion	.055	.426
Stereotypes	**-.151**	**.034**
Expectations	.083	.254
Willingness to eat more eggs	**-.141**	**.031**
External reports	-.092	.190
Moreish	**.194**	**.003**
Medical factors	-.108	.117
Suitability	-.028	.650
Familiarity	-.033	.586
Size	-.034	.580
Food safety	-.060	.351
Sensory	.037	.614
Eating less with aging	**.213**	**.009**
Protein intake frequency	**.237**	**.000**
BMI	**.172**	**.006**
Years of education	-.073	.248

4.3.5 Favourite type of eggs

As mentioned in the methods section, 19 extra statements on reasons for eating or not eating eggs were included about people's 'favourite type of egg'. Unfortunately however, only 102 respondents had filled in the section about what their favourite type of egg is. Including those responses, the regression model did not significantly predict specific egg type intake (R = .274, R^2 = .075, adjusted R^2 = -.038, F(11,90) = .662, p = .771)

4.3.6 Distribution of protein intake

For each food in the FFQ the participants were also asked to indicate when in the day they would normally eat this type of egg/protein rich food. Frequencies of responses are reported in tables 4.6 and 4.7. Many participants did not fill in this section, and some participants gave several answers per food. However, the numbers still clearly show that specific types of egg and protein rich food are popular for specific times of day.

The frequencies for types of egg in table 4.6 suggest that boiled eggs (hot), fried eggs, scrambled eggs and poached eggs are mostly eaten for breakfast, while omelettes, quiches and desserts (custard, meringues, and sweet flan) were mostly eaten for an evening meal. Egg salads, egg sandwiches and hard boiled eggs were most popular to eat at lunch. Table 4.7 shows that after breakfast cereals, bread and milk, eggs are most often eaten for breakfast, although eggs are more frequently eaten for lunch, and they are eaten to a similar amount as an evening meal as for breakfast.

Table 4.6 Frequencies of responses for each time of day different types of egg are normally eaten. Questions were not filled in by all participants, and participants could give several answers per food.

	Breakfast	Lunch	Evening meal	Snack
Boiled eggs (hot)	97	51	33	16
Hard boiled eggs (cold)	7	98	43	42
Fried eggs	90	43	51	8
Scrambled eggs	86	61	48	10
Poached eggs	63	55	39	11
Omelettes	15	75	97	9
Scotch eggs	0	31	12	43
Quiches	0	61	81	22
Egg sandwiches	3	102	12	37
Egg salad	0	62	45	13
Custards	0	18	105	23
Meringues	0	12	78	28
Sweet flan	0	13	62	16
Duck or Quails eggs	2	5	3	4
Raw eggs	0	0	2	2
Yolk separate	0	3	5	4
White separate	0	1	7	3
Other	1	1	4	3

Table 4.7 Frequencies of responses for each time of day different types of protein rich foods are normally eaten. Questions were not filled in by all participants, and participants could give several answers per food.

	Breakfast	Lunch	Evening meal	Snack
White meat	4	66	181	16
Red meat	2	35	175	6
Processed meat	50	118	73	25
White fish	1	42	172	2
Oily fish	3	73	111	12
Seafood	0	46	78	21
Eggs and egg dishes	95	116	92	26
Vegetarian meat substitute	1	9	39	5
Milk	107	33	22	45
Milk in tea or coffee	147	125	108	103
Yoghurts, custards, blancmanges	35	71	92	40
Hard cheeses	4	129	61	81
Soft cheeses	2	97	36	64
Nuts and seeds	40	15	14	117
Pulses	5	31	66	5
Beans or peas	16	68	172	12
Bread	110	133	41	64
Breakfast cereals or porridge	175	2	3	14

4.4 Discussion

The results reveal that the items included in the questionnaire can significantly predict egg consumption in the target sample. The significant predictors of egg intake that were shown in this study indicate the possibilities of many different strategies to increase egg intake in the target population. The results suggest that strategies to increase egg consumption should focus on: improving liking, tastiness and adding variety; less focus on eggs as value for money; eating eggs as an everyday type of food; reducing stereotypes about who does and who does not consume eggs; willingness to increase egg intake; making it easier to eat more eggs after initial tasting; and by promoting eggs for people who have noticed the effects of ageing on their food intake. The results also showed that higher protein intake of non-egg protein rich foods and a higher BMI were related to greater egg intake. The outcomes will be discussed below, followed by the strengths and limitations of this study.

4.4.1 Significant determinants of egg intake

Liking and flavour are important determinants of eating behaviour in the elderly (Locher et al., 2009), and variety is also well known to increase food intake (Brondel et al., 2009; Hollis & Henry, 2007; Marshall, Stumbo, Warren, & Xie, 2001; Rolls et al., 1981; Zandstra, de Graaf, & Van Trijp, 2000). Studies have shown that changing the flavour by adding spices, flavour enhancers or sauces can increase intake of protein rich foods in older adults (Appleton, 2009; Best & Appleton, 2011; Mathey et al., 2001). The use of several different added flavours also provides the possibility of increasing the hedonic variety of the diet. Increasing variety increases intake in older adults (Hollis & Henry, 2007).

Value for money was negatively related to egg intake, which seems unexpected because in many other studies low cost is thought to be an important positive determinant of food intake (Lewis & Bashin, 1988; Locher et al., 2009; Steptoe et al., 1995). A recent report showed that price is the most important factor influencing consumer product choice (Office-for-National-Statistics, 2016). Although, in consumer surveys on judging the quality of eggs, price was ranked as one of the least important factors (Hernandez, 2006). Table 4.3 showed value for money has the highest minimal score, and the second highest mean score. This indicates that participants mostly agreed with the component, participants who eat fewer eggs just agree stronger. The relation between cost/value for money and food choice is complex. Steptoe and colleagues showed that price was a more important determinant of food choice for people with low incomes compared to people with high incomes (Steptoe et al., 1995), but eggs have previously been reported as a food more commonly consumed in households with lower incomes (Appleton et al., 2007; Fearne & Lavelle, 1996b). Income was not measured directly in this study, but egg intake was not related to (previous) employment level so the regression model with the components did not control for employment level. Egg intake was, however, negatively related to education level. People with higher education are more likely to buy organic and free range eggs than people with lower education (Bejaei et al., 2011), these types of eggs may be perceived as better quality and healthier (Harper & Makatouni, 2002), but also tend to be more expensive than non-free range eggs. Data on which type of eggs participants buy was not collected, so it is unknown whether participants with higher education levels did buy different egg types than the participants with lower education levels. The regression model controlled for education and higher egg intake is still associated with less strong agreement that eggs are good value for money. If stronger feelings about the component value for

money are associated with lower egg intake it is important not to focus strategies on this. When a separate linear regression was run for the component ‘value for money’ the model did not significantly predict egg intake. This suggests that value for money only significantly explains variance in egg intake while the other components are independently explaining other parts of the total variance, it does not predict egg intake on its own.

The results also showed that higher egg intake was related to less strong adherence to stereotypes. Consumption stereotypes have been associated with gender roles, social appeal, morality, intelligence, and health; and could affect food intake through using eating for impression management or influencing self-image (Vartanian et al., 2007). These stereotypes are likely to be different between different cultures, generations, and between individuals (Ruby & Heine, 2012; Thomas, 2016). High egg consumption is often associated with intake of processed meats, e.g. bacon and sausages (Hu, Stampfer, Rimm, et al., 1999; Ruxton et al., 2010). If eggs are seen in a more “traditional” way, e.g. as part of a fried breakfast, it might be associated with masculinity, unhealthy foods, working class, and maybe even financial difficulties (Moss, 2014). While associating eggs with vegetarianism, sports or weight loss programmes could be related to healthy foods, being environmentally friendly, feminine, and upper class. Either way, stereotypes could have an impact on food choice. A qualitative study reported older adults worry about consumption stereotypes mentioning that not having confectionary would imply to visitors that you live like a “pauper” (Delaney & McCarthy, 2011). In the current sample a less firm adherence to stereotypes about the type of person who eats eggs was associated with greater egg intake, suggesting that whatever the stereotypes are, they seem to be a barrier to higher egg intakes and could preferably be changed. Although stereotypes are shown to be resistant to change in a natural environment (Johnston & Macrae, 1994), using social norms and strategies like social modelling have shown to be successful at changing eating behaviour (Herman, Roth, & Polivy, 2003; Robinson, Fleming, & Higgs, 2014). Older adults may show weaker social cohesion than younger adults, because they are known to be heterogeneous (den Uijl et al., 2014; van der Zanden et al., 2014b). Segmentation of older adults has been shown specific to eating behaviour, and acceptance of protein enriched foods (den Uijl et al., 2014; van der Zanden et al., 2014b). With the limited work on food stereotypes and social norms in older adults, it is unknown how the potential poor social cohesion may affect the influence of reference norms on eating behaviour.

The fact that eggs were advertised as ‘Go to work on an egg’ in the 1960s (British-Egg-Industry-Council, 2016b), might explain why many people of this generation think of eggs as an everyday life type of food rather than a food you serve to others. Eating eggs as an everyday type of food was positively related to egg intake in this study, and has been reported before in younger adults, eggs are considered very convenient, a staple food (Fearne & Lavelle, 1996b; Lewis & Bashin, 1988), and are eaten very habitually (Conrad, Johnson, Roemmich, Juan, & Jahns, 2017). Habits play an important role in eating behaviour (van’t Riet et al., 2011). Habitual intake of a certain amount of eggs may be even difficult to change if participants are not willing to increase their intake. For a survey about fruit and vegetable intake in older adults, one of the most common barriers to eat more was that they would not want to eat more fruit and vegetables because they believe they already eat enough fruit and vegetables, while intake was often not high enough (Appleton et al., 2010). In a recent study, Conrad and colleagues showed that the large NHANES database of almost 30.000 US adults showed no change in proportion of the population who eats eggs over 10 year follow up. Mean daily egg intake increased, but only for those who are food secure, food insecure people did not increase. Their results suggest that eating more eggs may be related to changing less (Conrad et al., 2017). The results of the current study show that people with a relatively high egg intake do not want to consider eating more eggs than they already do. In the focus groups, participants often showed strong opinions about how many eggs per day or per week they think is enough or sufficient. The relatively high egg consumers in the current study may be eating the amounts of eggs they think are sufficient for them, and therefore may not consider eating more eggs. The results, however, also indicate that people with a relatively low egg intake show a greater willingness to eat more eggs. This could facilitate behaviour change in the people who need it most.

Moreish can be seen as a combination of liking and availability. For someone to not want to stop eating eggs once they started eating them, they must be liked and available to them. Eggs are not a typical moreish food, because they need (simple) preparation. Whether eggs are moreish is considered to be egg type and context dependent. In the case of (pieces of) Spanish omelette, quiche or scotch eggs, they could be readily available in amounts bigger than a standard portion, and therefore could be moreish. Another way in which this component applies to eggs could be (breakfast) buffets where eggs are available. Many studies have shown that making foods more readily available, removing visual cues of portion size (by serving it in

smaller portions), or buying in bulk can increase intake (Wansink, 1996; Wansink, Painter, & Lee, 2006; Wansink, Painter, & North, 2005). The specific portion size of eggs may limit people's intake, where a specific number of eggs (e.g. one or two) will be used per meal. Cooking dishes with more than one portion (e.g. quiche or Spanish omelette), may help to overcome the standard portions limiting egg consumption.

The variable eating less with ageing was positively related to egg intake, suggesting that older adults with more difficulties with food preparation and shopping, sensory impairment and loss of appetite tend to eat more eggs. Food intake for adults decreases about 25% from 40 years old to 70 years old (Nieuwenhuizen et al., 2010). There are a number of physiopathological, psychological, and social reasons why older people tend to eat less food or different foods than younger adults (Donini et al., 2003; Hetherington, 1998; Nieuwenhuizen et al., 2010; Roy et al., 2016), and protein rich foods specifically (Appleton, 2016; Best & Appleton, 2013; Deutz et al., 2014; Volpi et al., 2013). Sensory abilities and physical abilities have an important impact on dietary intake in older adults (Allaire et al., 1991; Doets & Kremer, 2016; Wylie et al., 1999). Compared to other protein rich foods, eggs have a soft texture, and are easy to prepare, which makes them relatively easy to eat for older adults with sensory or phyical impairments.

The current study also showed a higher BMI and higher total protein intake with higher egg intake. There are indications that egg intake is related to unhealthy lifestyle factors including smoking and physical inactivity, and unhealthy eating patterns including high intakes of SFA, total energy and intake of processed- and red meats (Djoussé et al., 2009; Hu, Stampfer, Rimm, et al., 1999; Ruxton et al., 2010). Due to the cross sectional nature of the study, the direction of causality in the relation between BMI and egg intake is unknown. Moreover, the association between higher BMI and higher intake of eggs may be confounded by SES. SES is known to be related to diet quality (Roos, Prättälä, Lahelma, Kleemola, & Pietinen, 1996; Turrell, Hewitt, Patterson, Oldenburg, & Gould, 2002) and BMI (Rosmond & Björntorp, 1999). The link between more frequent egg consumption and more frequent intake of other protein rich foods suggests people may not substitute high egg intake by eating less of other protein rich foods, but tend to either have a high intake or low intake of all protein rich foods including eggs. As mentioned above, eggs have been associated with high intakes of processed and red meats (Hu, Stampfer, Rimm, et al., 1999; Ruxton et al., 2010).

The statements about favourite type of egg did not predict intake of favourite type of egg. Unfortunately not many participants filled in this section, which suggests the participants did not understand what was expected from them. This could have influenced the result, or these particular reasons just do not predict egg intake. It could be that even though a type of egg preparation is a person's favourite, they might not all have their favourite egg type very often. A favourite type of egg could be a treat, something you only eat occasionally (maybe only when eating out).

The questions about time of day each food is normally eaten were also not filled in by all participants, which indicates the question may have been confusing. The limited results however still show that eggs are eaten for each meal but are particularly popular for breakfast . Additionally it showed that specific types of eggs are often eaten at specific times of day. Eggs have been reported as a familiar and acceptable breakfast food in the UK (Smith & Gray, 2016), these frequencies confirm this.

4.4.2 Strengths and limitations

It should be noted that the food frequency measure used to assess protein intake is not very detailed or rigorous. It contains categories of foods including different products, does not include number of times eaten per day or portion size, or account for protein content differences between the different foods. It should merely be interpreted as an indication of number of times a type of protein rich food is eaten/drunk by the participant.

With interpreting the results the egg intake measure should be seen as an indication of habitual intake frequency. The food types listed are clear, but like in the protein intake measure, the frequency measure does not give the option to enter how many times per day eggs are consumed, and it is not possible to give an indication of portion size. Moreover, if the participants do not eat eggs as part of a routine, it might be difficult to fill in how much is usually consumed. For three participants the egg intake was classified as an outlier, and therefore excluded from the final data analysis. The egg intake values included 92.5, 101.25, and 300 eggs per month. Because the new egg intake measure was not validated, it was thought to be more rigorous to exclude these as outliers. This Food Frequency type of intake measure is commonly used, and has been shown to be a valid measure of intake of the

elderly (Smith, Mitchell, Reay, Webb, & Harvey, 1998; Tyrovolas, Pounis, Bountziouka, Polychronopoulos, & Panagiotakos, 2010). For this questionnaire, a food frequency questionnaire (FFQ) was chosen to reduce questionnaire length and difficulty. For habitual intake a more detailed FFQ or food diary would be more ideal, but this would be time consuming for this questionnaire, and it was thought that this might reduce response rates. A 24hour dietary recall would possibly be too difficult (and therefore inaccurate) for older adults. Furthermore, this measure would be biased by the irregular consumption of eggs, especially since each individual's intake is important in the analyses. The questionnaire as sent out to the participants was a compromise of the number of variables to be assessed, clarity (font size), and length of the questionnaire. Despite the effort to keep it as short as possible, it was nine pages (including intake measures and demographics). Although the pilot participants only took around 20 minutes to complete it, this might have affected the response rate.

The components were generated using principal component analysis and Cronbach's alpha values based on the initial responses with 182 participants. New Cronbach's alpha values were generated for the final sample (N=230), and reported in table 4.2. Two of those components the Cronbach's alpha values decreased to be below .5, while they were above .5 for the initial sample. Cronbach's alpha values are generated to test internal consistency/ reliability of the components. This suggests the components 'Willingness to eat more' and 'Expectations' cannot be considered reliable in the current sample. Unfortunately the initial response rate was relatively low; therefore the components were based on a smaller sample. After sending out reminder questionnaires more responses were collected. This sample is thought to be more representable of the older population than just the older adults who respond quickly to the first questionnaire, but the decreased reliability needs to be considered when interpreting the results.

It was considered a strength of the study that recruitment focussed on a sample that is representative of the UK older population. Unfortunately, the sample of responders was significantly different when statistically compared with the Census 2011 (Office-for-National-Statistics, 2011). The regional proximity bias is however, not unexpected and can be seen in other studies (Appleton, 2016). Appendix 4.3 shows that the South West region where Bournemouth University is based was over-represented, and Scotland was underrepresented. Since egg consumption and attitudes to eggs are not markedly different regionally (from personal communication

with British Egg Industry Council), this is not expected to affect the results. The over-representation of 65-79 year olds might be due to available free time and relatively lower levels of frailty, while the under-representation of 55-59 and 80+ year olds might be due to lack of free time, and frailty, physical or visual impairment. When the regression model was run including age group and region to control for these factors, the significant predictors of egg intake remained the same.

Other possible forms of response bias might be a lower response from people who do not like eggs, although the responses include some low intakes, and the need to exclude people with allergies to eggs shows that at least some people with low liking/intake of eggs have returned the questionnaire. Moreover, the number of low consumers would be expected to be low, as the household penetration of eggs is very high (from personal communication with British Egg Industry Council). Additionally, the demographic characteristics of the current sample show a relatively high employment level. This volunteer bias might be a result of literacy difficulties, and is a limitation of this study. The participants were offered an option to respond to the questions over the phone, but no one took this option. Lastly, because of the cross sectional nature of the study, the direction of causality is unknown.

4.5 Conclusions

The outcomes of this study inform us of the reasons that differentiate people with high and low intakes of eggs, and on which reasons a strategy to change egg consumption should focus. The results suggest that strategies to increase egg consumption should focus on: improving liking, tastiness and adding variety; less focus on eggs as value for money; eating eggs as an everyday type of food; reducing stereotypes about who does and who does not consume eggs; willingness to increase egg intake; making it easier to eat more eggs after initial tasting; promote eggs for people who have noticed the effects of ageing on their food intake.

For the next study of this PhD project, the component including the reasons liking, flavour, variety and balanced diet was the main focus. Using recipes to provide participants with ideas to increase variety and add flavour to egg dishes, the effect of the intervention on egg intake, protein intake, and various physical measures was assessed in a randomized controlled trial.

5. Increasing egg and dietary protein intake in community dwelling older adults: a randomised controlled trial

5.1 Introduction

Chapter 2 of this thesis reviewed the literature about protein specific under-nutrition, the importance of dietary protein for older adults, and how eggs may help to increase protein intake in older adults. Reasons for eating or not eating eggs in adults aged 55 years and older were identified in a focus group study (chapter 3) and then used to design a structured questionnaire which was sent out to a National sample (chapter 4). The questionnaire results showed that older adults who eat more eggs report that they like eggs, think eggs taste good and add variety to the diet. The current study was designed to impact all three factors together, not liking, flavour and variety separately. Liking of food is often closely related to intake of the food (Appleton, 2016). Previous work has shown that in children liking and intake of a food can be increased by repeated exposure to the taste of the food (Caton et al., 2013). Adding flavour and more variety to egg based meals may encourage intakes in those who consume fewer eggs. Adding variety and flavour are known to affect food intake in older adults (Hollis & Henry, 2007; Mathey et al., 2001) and specifically protein intake (Appleton, 2017a; Appleton, 2009; Best & Appleton, 2011). The main aim of this study was focussed on increasing flavour and variety, which may influence liking and intake directly or indirectly through repeated exposure.

Studies have shown that eating in older adults is strongly driven by habits and past behaviour (Best & Appleton, 2013; Edfors & Westergren, 2012; Falk et al., 1996), and is likely to be monotonous (Denison, Cooper, Sayer, & Robinson, 2015; Fanelli & Stevenhagen, 1985; Nieuwenhuizen et al., 2010; Pelchat & Schaefer, 2000). However, with nutrition focused workshops and education older adults can change their eating behaviour, learn to cook new meals, and add more variety to their diet; Cooking lessons can increase cooking variety (Keller, Gibbs, Wong, Vanderkooy, & Hedley, 2004), and change dietary intake (Hirakawa et al., 2003; Yim, 2008). Older participants indicated that the new recipes provided were one of the key aspects to

success and empowerment of behaviour change (Keller, Hedley, Hadley, Wong, & Vanderkooy, 2005). The results of a study with younger adults even suggest that sending recipes to participants' homes may have similar effects to taking part in cooking lessons (Wenrich, Brown, Wilson, & Lengerich, 2012). Unfortunately these studies did not focus on increasing protein intake, or egg intake.

Individuals are exposed to new recipes in everyday life, printed in magazines or on food packages, available in supermarkets or shops, or part of television programmes (De Solier, 2005; McKie & Wood, 1992; Villani, Egan, Keogh, & Clifton, 2015), and it has been shown these types of recipes can affect food choice (Moore, Earless, & Parsons, 1992; Papies, Potjes, Keesman, Schwinghammer, & Van Koningsbruggen, 2014; Papies & Hamstra, 2010). A large survey with over 5500 British adults (16-74 years old) showed that cookbooks, cooking programs on television, and magazine/newspaper articles are the three main sources to learn more about cooking (Caraher, Lange, & Dixon, 2000). These types of recipes could reach a larger group of people than the interventions with cooking lessons or personal advice (Caraher et al., 2000; De Solier, 2005).

Recent work on dietary protein recommendations suggests that on top of a high enough total daily intake, it is important to reach a threshold of 25-30g of high quality protein per meal for optimal stimulation of muscle protein synthesis in older adults (Murphy et al., 2016; Paddon-Jones & Rasmussen, 2009). Studies have demonstrated that protein intake distribution over the day is generally skewed to the main meal (a hot meal at either lunch or dinner time) and particularly low for breakfast (Berner et al., 2013; Mamerow et al., 2014; Tieland, Borgonjen-Van den Berg, et al., 2012; Valenzuela et al., 2013; Volpi et al., 2013). Every extra meal per day of reaching the optimal protein threshold is associated with significantly higher muscle strength and lean body mass (Loenneke et al., 2016). Higher muscle strength and lean body mass are associated with higher quality of life and improved physical abilities in daily activities (Cruz-Jentoft et al., 2010). This suggests that many older adults would benefit from increasing dietary protein intake, especially at meals that are generally low in protein. There is a small number of intervention studies using conventional foods, but the foods used to increase protein intake may not be appropriate or acceptable in the UK as a food for breakfast or other non-main meals (e.g. lean red meat, (Daly et al., 2014; Torres et al., 2017), or ricotta cheese (Alemán-Mateo et al., 2014)). For a food based approach it is important that the type of food used is acceptable to the participants and appropriate for the time of

day. Eggs are generally acceptable for breakfast or smaller meals in the UK (Smith & Gray, 2016).

If exposure to high protein egg based recipes specifically designed to add variety and flavour to protein rich meals for older adults would inspire individuals to use the recipes, this may increase intake of eggs and other protein rich foods. If recipes are focused on breakfast, this may encourage protein intake for a meal that is generally low in protein. Providing recipes could therefore be a straightforward to implement, and cost-effective strategy to increase protein intake in older adults. To the author's knowledge no intervention studies have used recipes to increase egg and protein intake in British older adults.

This study aims to increase egg intake, and protein intake, in community dwelling individuals aged over 55 years old, by providing recipes and complementary herb/spice packets to increase the flavour and variety of egg dishes. Therefore a parallel group, randomized controlled intervention study was designed to investigate whether sending high protein egg based recipes and herb/spice packets to people's homes could increase egg intake and total protein intake, measured after the three month intervention and at the six month follow up.

The following hypotheses were raised:

- Egg intake will be higher in the intervention group than in the control group after the three month intervention period, and at the six month follow up.
- Protein intake will be higher in the intervention group than in the control group after the three month intervention period, and at the six month follow up.
- Protein intake from animal sources will be higher in the intervention group than in the control group after the three month intervention period, and at the six month follow up.
- Measures of lean body mass, muscle strength and physical performance will be higher in the intervention group than in the control group after the three month intervention period, and at the six month follow up.

5.2 Methods

5.2.1 Sample size

Data from the National Diet and Nutrition Survey (NDNS) show that UK adults over 65 years old have a mean daily protein intake of 69.8g (SD = 20.3) (Bates et al., 2014). To reach the threshold to stimulate muscle protein synthesis at an intake of 25-30g of protein per meal (Paddon-Jones & Rasmussen, 2009) for three meals per day, daily intake should be at least 75-90g per day. Taking the average of 82.5g, this means that an increase of 12.7g of protein per day is needed. Assuming no change in the control group over the intervention period, and based on an Alpha (Type I error) of 5%, and a Beta (Type II error) of 20%, the required sample size was calculated in the following way:

$d = (\mu_D - \mu_0) / \sigma$
$= (82.5-69.8) / 20.3$
$= 0.63$

$N = 2 (\delta / d)^2$
$= 2 (2.80 / 0.63)^2$
$= 40.06$

Based on this calculation, and taken into account a possible drop-out of 20%, the study was aimed to include 50 participants in each group, with the total sample size of the study aimed at 100 participants.

5.2.2 Participants

Participants were considered for inclusion if they were:

- 55 years and over
- living in the community
- able to give consent
- not allergic to eggs
- not suffering from known renal insufficiency, or having a pacemaker or defibrillator
- not suffering from known hypercholesterolaemia, or known familial hypercholesterolaemia

- not having undergone chemotherapy or radiotherapy in the last 6 months
- not suffering from any condition, or receiving medication or treatment that the participants felt affects their eating or sense of flavour

Individuals with renal insufficiency were excluded because they are recommended to restrict dietary protein intake (Pedrini, Levey, Lau, Chalmers, & Wang, 1996). Individuals with a pacemaker or defibrillator were excluded because of a concern that the method used for measuring body composition (Bioelectrical Impedance Analysis (BIA)) could potentially interfere with the pacemaker or defibrillator function, this is a general recommendation for the measure. Individuals with (familial) hypercholesterolaemia were excluded from the study because they are advised to restrict dietary cholesterol intake, and therefore should restrict egg intake (British-Heart-Foundation, 2015). An allergy, medical condition or treatment would have a big impact on eating behaviour (Jcobsen et al., 1993; Steinbach et al., 2009; Van Cutsem & Arends, 2005). Eating behaviour specific to allergies and medical conditions or treatments is beyond the scope of this project.

Energy intake and basal metabolic rate ratio (EI:BMR) cut-offs are recommended to assess misreporting (Wrieden, Peace, Armstrong, & Barton, 2003), but these cut-offs are based on the assumption that body weight is stable (Livingstone & Black, 2003). In an elderly population it cannot be assumed weight and body composition are stable (Hughes, Frontera, Roubenoff, Evans, & Singh, 2002). Therefore, participants for this study were not excluded based on intake data from the Food Frequency Questionnaire (FFQ).

5.2.3 Recruitment

The participants were recruited in different ways. People in the target age group who have volunteered in previous studies were contacted, as well as organisations that run group meetings within the target population (e.g. bridge clubs) or by flyers and posters at local general practitioner's offices, museums, and libraries. All participants were contacted by email or telephone, asking about the different inclusion criteria listed above, and they were sent a participant information sheet before coming for the first test session. Participants were not informed about the aim of the study. They were instead told the project is studying habits and lifestyles in older adults.

5.2.4 Randomisation

All individuals who were considered eligible (meeting the inclusion criteria) and willing to take part were randomized into one of two groups, which were referred to as the intervention group and the control group. This randomisation was stratified per ten year age group (55-64, 65-74, 75-85, 85+), so that the intervention and control group had similar numbers of participants within each age group. Randomization was also stratified by involvement/not in the earlier focus groups – for the participants who had participated in the focus group study about eggs described in chapter 3, the randomization included a roughly equal dividing of previous participants over the intervention and control group. Couples were always allocated to the same group. A researcher not in direct contact with participants (PhD supervisor) undertook the blocked randomization (using blocks of 6-10 participants) and sent all materials (e.g. the recipe sets including herb/spice packets) for intervention participants at the correct time. The researcher of this study, did not know which participants were allocated to which group, until all the data was collected. This form of blinding minimized any possible differential treatment of the participants by the researcher taking the outcome measures. The researcher was blind to participant allocation during the assessment of all outcomes. Participants were not blind, although they were blind to the other possible conditions. The control group did not know about the intervention.

5.2.5 Study design

A schematic overview of the study design can be found in figure 5.1. All participants came to Bournemouth University for a test session at baseline (T1), another test session after three months (T2), and a follow up test session six months after baseline (T3). A week before the test session, participants received a set of questionnaires by post to their home address, and were asked to fill them in and bring them to the test session, where any queries could be discussed. The questionnaires were filled in and returned after the test session. At a few exceptions, the participant finished the questionnaires at home within a few days after the test session, and returned them by post to the researchers. All test sessions were in the morning starting between 8.00 and 11.00, at a time of the participant's preference. Participants came fasted, and were asked to have had only water to drink since going to sleep the night before the test session. Height and weight were measured first, followed by a bioelectrical impedance measure of body composition. After these measures, a standard breakfast of toast/cereal and

coffee/tea was provided. While the participant was eating breakfast, their questionnaires were checked for missing values and any queries were discussed with the researcher. After breakfast the physical performance measures (Short Physical Performance Battery (Guralnik et al., 1994)) and muscle strength measures (handgrip strength and leg extensions) were assessed. Measures are described in detail below in section 5.2.7-5.2.12. Measures at test sessions and in the questionnaires were the same for each of the test sessions, with two extra questionnaires at T1. At the baseline test session, the questionnaire set included a questionnaire about demographic characteristics and lifestyle factors, and a questionnaire about reasons for eating eggs. The T1 session also started with the researcher explaining the inclusion criteria and study procedure to the participants and the participant signing informed consent. Test sessions were individual, or if preferred per couple, and lasted about an hour per person. After the baseline test session, all participants received a postcard with a short dietary information message, including the importance of dietary protein for older adults and why it may be beneficial to eat more protein, and to do so for breakfast. A copy of the dietary information postcard can be found in appendix 5.1.

5.2.6 Intervention

The participants allocated to the intervention group received recipes which were sent to the participants' home address every two weeks for 12 weeks. The recipes provided included suggestions for breakfast meals, but could be eaten for lunch or dinner. Each recipe included 25-30g of protein, and one or two eggs per meal. The recipes provided ideas for preparing eggs in different ways, adding different flavours. This variety of egg dishes provided the opportunity to increase variety in the overall diet, and the ways to eat eggs. The herbs and spices used in the recipes were also provided to the participants. The intervention group participants received a recipe feedback form in the post after the T2 and T3 test sessions at three months and six months.

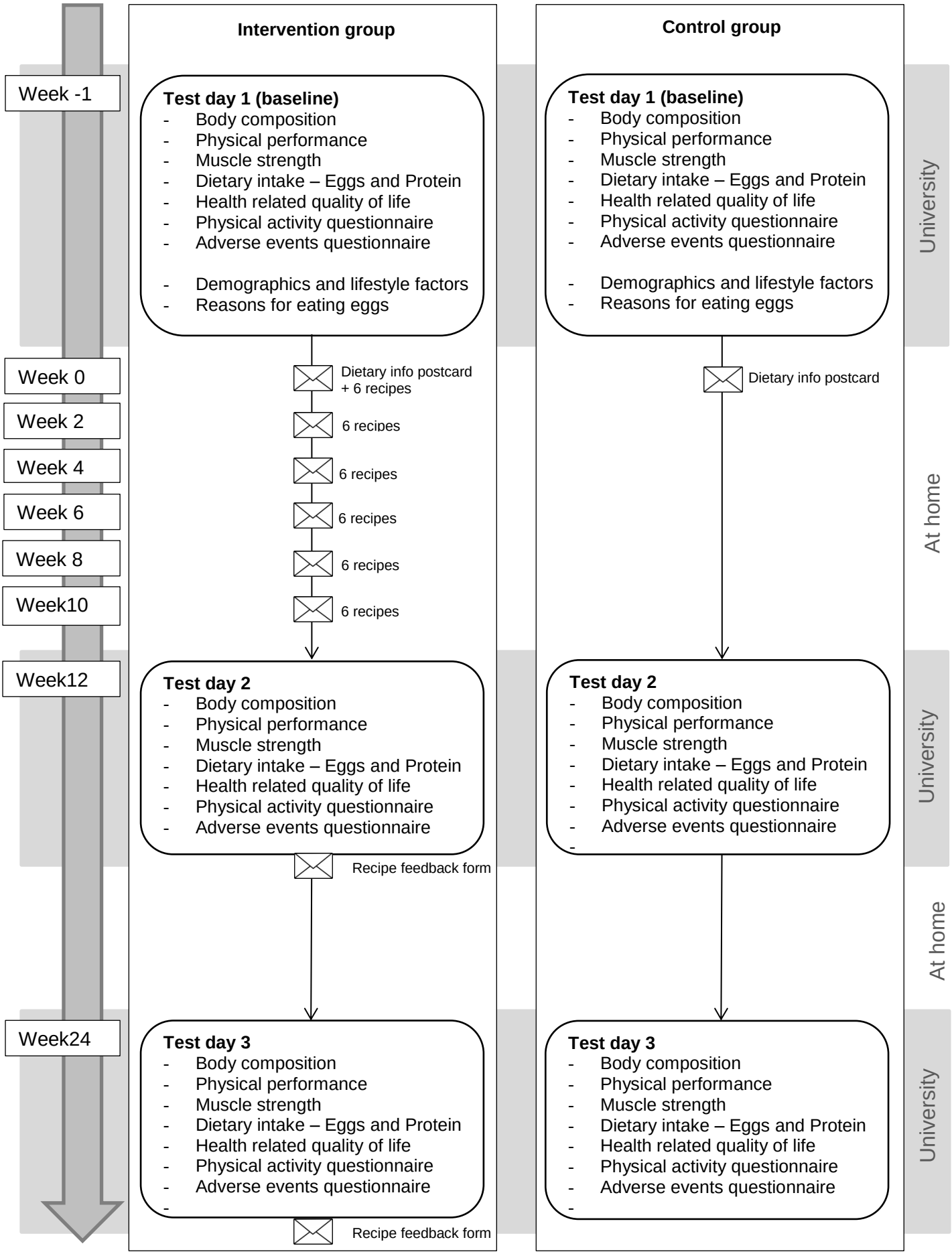

Figure 5.1 Schematic overview of the study design

Recipes

The 36 different recipes all contained eggs, and between 25 to 30g of protein. The recipes were gained from the website www.eggrecipes.co.uk, developed by the British Egg Industry Council (British-Egg-Industry-Council, 2016a), amended to contain 25-30g of protein. After amending the recipes, the recipe cards were pilot tested with individuals in the target age group. During a telephone conversation with the researcher, the older adults in the pilot study provided feedback on the use, appearance and clarity of the recipes. This was taken into account with the final changes to the recipe cards. The text on several recipes was altered for face validity. Participants in the intervention group received six sets of six recipes, one every two weeks between T1 and T2. Each set of six recipes was selected to include a variety of egg preparations (e.g. fried eggs, scrambled eggs, omelettes), a variety of preparation times and preparation methods (hob, oven, microwave), as well as a variety of vegetarian dishes as well as dishes containing meat or fish. Several of the recipes were developed by chefs known from UK television. This was thought to increase the 'status' of the dishes. The dishes were also selected to have a variety in flavours, e.g. Indian, Turkish, Moroccan, Italian dishes, or dishes that are more 'English' with bacon, cheese and/or ham. The recipes were printed in large clear text on A5 glossy paper, to be more hard wearing than normal paper and simulate the recipe cards from supermarkets. All herb/spices mentioned in the recipes were provided for one preparation of the dish. All the recipes reported the preparation time, as well as the nutritional composition, with the protein content highlighted in bold. All recipes mentioned the dish was high in protein, and were recommended to have for breakfast or brunch. Foods, other than herb/spice packets, were not provided to make it more comparable to everyday life exposure to recipes. This approach was chosen because laboratory settings can influence eating behaviour (Robinson, Hardman, Halford, & Jones, 2015), and the cost of food is an important determinant for food choice in older adults (Locher et al., 2009). In the real life setting of this study, participants needed to buy the ingredients if they chose to use one of the recipes. Recipes have previously demonstrated to be beneficial for this age group (Keller et al., 2005), and have been shown to be equally effective as cooking workshops for younger adults (Wenrich et al., 2012). Participants receiving the recipes were asked not to tell the researcher about the recipes. A list of all recipes can be found in appendix 5.2, and a recipe set of six recipe cards can be found in appendix 5.3.

Control

Participants in the control group also received the dietary information postcard after the baseline test session. They did not receive any recipes, herbs or spices, or the recipe feedback forms.

5.2.7 Outcomes- Dietary intake

Egg intake

Egg intake was measured using a Food Frequency Questionnaire (FFQ) measure of portion size and frequency. The egg FFQ included boiled eggs (hot), hard boiled eggs (cold), fried eggs, scrambled eggs, poached eggs, omelettes, scotch eggs, quiches/savoury flans, egg sandwiches, egg salad, custards, meringues, sweet flan/crème caramel, duck/quail's eggs, raw eggs, egg yolk separate from the white, and egg white separate from the yolk. The newly developed FFQ had a similar lay out to the Scottish collaborative group FFQ (SCG FFQ) which was used in this study to measure protein intake (Clark, 2017; Masson et al., 2003). Each type of egg had a measure, e.g. 1 egg, or 1 slice, and participants were asked to fill in how many measures they had per day (1, 2, 3, 4, 5+). They were also asked about the number of days per week they eat this type of egg preparation, answer options were 1 to 7 days per week, 'M' for once or twice per month, or 'R' for rarely or never. The responses were converted to number of eggs eaten per month. The category 'rarely or never' was counted as 0 times eaten per month, 'once or twice per month' as 1.5 times, and 1 to 7 days per week, as 4, 8, 12, 16, 20, 24, and 28 times per month. Most foods were counted as equal "units" or portions, except for the egg dishes custards, meringues, and sweet flan/ crème caramel. For these dishes each time consumed was counted as 0.5 portion, because a standard portion tends to be less than one egg while for the other dishes it is more likely to be one egg or more. The egg intake FFQ can be found in appendix 5.4.

Protein intake

Protein intake was measured using a validated FFQ, by the Scottish collaborative group, measuring frequency and portion size over the last two-three months (Clark, 2017; Masson et al., 2003). The food frequency questionnaire consists of 19 sections. The sections include: bread, breakfast cereals, milk, cream and yogurt, cheese, eggs, meats, fish, potatoes, rice and pasta, savoury foods, soups and sauces, vegetables, fruit, puddings and desserts, chocolates, sweets, nuts and crisps, biscuits, cakes, spreads and sugar, beverages and soft drinks, and alcoholic

drinks. The food intake data were converted to total daily intake of energy, protein, fat and carbohydrate per day and per section by the Scottish collaborative group (Clark, 2017). Daily protein intake and energy intake were used to assess whether protein intake would change over time, and whether the sources of protein would change. Protein intake was measured because it is known to be related to egg intake (Ruxton et al., 2010), and to muscle mass, strength and function (Houston et al., 2008; Loenneke et al., 2016; Tieland, van de Rest, et al., 2012). In chapter 4, section 4.3.4, also showed that egg consumption was significantly related to protein intake frequency.

The SCG FFQ section on egg intake consists of three questions. The participants were asked: how many measures (eggs) per day, and the number of days per week they eat 'Boiled or poached eggs', how many measures (eggs) per day, and the number of days per week they eat 'Fried eggs', and how many measures (eggs) per day, and the number of days per week they eat 'Scrambled eggs or omelette'. The responses to this section were converted to monthly egg intake and used to compare with egg intake measured with the new scale detailed above.

5.2.8 Outcomes - Body composition

Standing height was measured in meters to the nearest 0.1cm, without shoes, using a stadiometer (SECA gmbh & co, Hamburg, Germany). Body weight was measured with a calibrated scale (The Boots Company PLC, Nottingham, UK) in kilograms to the nearest 0.1 kg, without shoes, dressed in light clothing. Both measures were converted to Body Mass Index (BMI). Body composition was further assessed by bioelectrical impedance analysis (BIA) with the use of a 50-kHz generator (1500 MDD; Bodystat, Isle of Man, UK). The device sent a low electrical current through the body by way of electrodes on the participant's hands and feet. Because the resistance or impedance of fat and muscle tissue is different, fat free mass can be assessed. The procedure is commonly used, validated, and a non-invasive way to measure lean body mass (Janssen, Heymsfield, Baumgartner, & Ross, 2000; Janssen, Heymsfield, et al., 2002). All participants were asked to come in after an overnight fast, to only have water to drink after waking up and not have alcohol or caffeine for 12 hours prior to the measurement. For follow up sessions, they were reminded of the amount of water they drank for the baseline session and asked to keep this the same. Potential exercise or use of sauna during eight hours prior to the session was recorded, and the participants were all rested sitting back against

the back support on a massage table for at least a few minutes before the measure. Estimates of lean body mass provided were used for further analyses, and fat percentage was reported as part of the baseline measures. Under standard conditions, BIA measures are validated against MRI measures of skeletal muscle mass (Janssen, Heymsfield, Baumgartner, et al., 2000). The equations have been validated for adults of multiple ethnicities (Janssen, Heymsfield, Baumgartner, et al., 2000), and have been established and recommended for older adults (Cruz-Jentoft et al., 2010; Kyle, Genton, Slosman, & Pichard, 2001; Roubenoff et al., 1997).

5.2.9 Outcomes – Physical abilities

Physical performance

Physical performance was assessed using a short physical performance battery (SPPB) including several different activities to test lower extremity function (Guralnik et al., 1994). These measures are relatively quick, include activities that are used in everyday life, and are non-invasive for the participants. Performance on this battery of measures has been linked to self-reported disability, and predicts mortality and nursing home admission (Guralnik et al., 1994). The SPPB consists of three physical functioning tests measuring: lower body strength (chair stands), standing balance, and walking speed (8-foot walk). For the chair stands the participants were asked to stand up from a chair and sit down five times with the arms across the chest while the experimenter measures the time. For the balance test, the participants were instructed to try to stand in different positions: side-by-side, semi-tandem, and full-tandem position, while being timed until they lost their balance or until they held the position for 10 seconds. Walking was measured by asking the participant to walk an 8-foot walking course with at least 2 feet at either end at their usual speed, just as if they were walking down the street to go to the shop. Two times were recorded for walking 8-foot, of which the fastest is used for analyses. Scores from zero to four are derived for each of the three components and added up to one score following the instructions by Guralnik et al. (Guralnik et al., 1994). Total SPPB score ranges from 0 to 12 with a higher score indicating better physical performance. The SPPB has been recommended for measuring physical performance in frail old people (Cruz-Jentoft et al., 2010). Statistically significant improvements in SPPB scores have been found in older adults following increased protein intake (Tieland, van de Rest, et al., 2012) and the method can measure clinically meaningful changes (Kwon et al., 2009).

Muscle strength

Handgrip strength was measured using a hand grip dynamometer (Takei, GRIP-D, T.K.K. 5401) (Watanabe et al., 2005). Participants were asked to take three measures of handgrip strength for each hand, alternating between right and left hands, while standing up (or sitting if standing was not possible). The maximum of the six measures was reported (Roberts et al., 2011). Leg strength was measured in seated position by counting how many times participants can extend their leg wearing ankle weights (of 5kg, 2.5kg, or no weights) during a set amount of time (one minute or 30 seconds). During the first test session ankle weight and time was chosen based on estimated ability of the participant, judged by the researcher after the participants had performed the other exercises. The 2.5kg weights and one minute duration were chosen for most participants unless participants were particularly strong or weak. After the first session the same weights and duration were used for the other test sessions, if this was not possible (e.g. due to injuries) the data were excluded from analyses. Handgrip strength and leg extension are commonly used non-invasive measures to assess muscle function in older adults (Beasley, Shikany, et al., 2013), and only took a few minutes to measure. These measures of muscle function have been associated with health related quality of life (Sayer et al., 2006), nutritional status (Norman, Stobäus, Gonzalez, Schulzke, & Pirlich, 2011), and future physical performance and disability (Rantanen et al., 1999). Handgrip strength relates strongly to lower extremity muscle power and mobility (Lauretani et al., 2003), and has been recommended for a quick and inexpensive sarcopenia screening tool (Lauretani et al., 2003). Sarcopenia cut off points per gender based on measured handgrip strength were used to estimate sarcopenia prevalence (Cruz-Jentoft et al., 2010; Lauretani et al., 2003; Murphy et al., 2017).

5.2.10 Outcomes - Confounding variables

Physical activity

Physical activity as energy expended in physical activity per week was assessed by asking participants to fill out the Community Healthy Activities Model Program for Seniors (CHAMPS), a physical activity questionnaire for older adults (Stewart et al., 2001). The CHAMPS questionnaire lists a variety of light, moderate and vigorous physical activities, to which the participants respond with their weekly frequency of

performing the activity, and the amount of hours per week (with multiple choice answers: less than 1 hour, 1-2.5 hours, 3-4.5 hours, 5-6.5 hours, 7-8.5 hours, and 9 or more hours). Following the developers' instructions for scoring, the responses were converted to four different outcomes: estimated energy expended per week on all activities and for activities of at least moderate intensity, and frequencies per week spent doing all activities and moderate intensity activities. Moderate intensity activities are: walking briskly, jogging, dancing, golfing without using a cart, singles and doubles tennis, riding a stationary cycle or bicycle, swimming, water exercises, aerobics, heavy household chores, and gardening. For all activities the following activities were added: walking leisurely, golfing with a cart, light housework, yoga, stretching/flexibility exercises, and general conditioning exercises. For the data analyses the estimated caloric expenditure per week on all activities was used. Physical activity is strongly related to muscle mass and strength (Cruz-Jentoft et al., 2010; Goodpaster et al., 2008), moreover a recent review showed that experience in exercise made the protein supplementation with resistance training more effective (Morton et al., 2017), and studies show that higher egg intake is related to low physical activity (Hu, Stampfer, Rimm, et al., 1999).

Health related quality of life

Health related quality of life (HR QoL) was assessed using the short form-36 questionnaire (SF-36) (Ware Jr & Sherbourne, 1992). The responses are converted to scores for nine different domains: physical functioning, limitations due to physical health, limitations due to emotional problems, energy/fatigue, emotional well-being, social functioning, pain, general health, and health change. Scores for the domains were generated following the instructions of the scale developers (Ware Jr & Sherbourne, 1992), and added up to a total SF-36 score. A higher score for each domain indicates greater self-perceived health; a higher total SF-36 score therefore suggests a greater HR QoL. Although the scale originally measures nine outcome domains, the SF-36 total score has been increasingly reported (Lins & Carvalho, 2016). For this study the total score (sum of the nine domain scores) was used to maximize power in statistical analyses, where adding more variables in the regression would have reduced the power of the analyses (Howell, 2012). SF-36 scores were measured because they have been associated with muscle strength and physical performance (Syddall, Martin, Harwood, Cooper, & Sayer, 2009).

5.2.11 Outcomes - Adverse effects

The participants were asked questions concerning potential adverse effects. The questions included a list of closed questions and open questions for the participants to indicate any adverse effects they may have encountered. The participants were asked whether during the previous month they experienced any of the following effects more of less often than usual: nausea, digestive issues (e.g. constipation or diarrhoea), stomach aches/cramps, hunger, bloating/uncomfortable fullness, thirst, headaches, fatigue/tiredness, restlessness, dizziness, or skin rashes. Lastly if they answered yes to any of the questions, they were asked whether they know why this was different than usual, and whether they had experienced anything else that was different than usual.

5.2.12 Outcomes - Additional outcomes

Demographic characteristics and life style factors

All participants filled out a questionnaire assessing demographic characteristics and life style factors, including: date of birth, gender, marital status (married, divorced, widowed, or never married), living status (alone or with others), education level (total number of years), nationality, and most recent level of employment (unemployed, manual worker, non-manual worker, or professional/management). Other questions included were about how often people receive help with food shopping or preparation; eat out or away from home, or whether they get food delivered (never, sometimes, or often), and questions about whether the participants are vegetarian, pescatarian or vegan (yes or no), and whether they wear dentures (no, partial dentures or full dentures). Age, gender, living situation, lifestyle and physical abilities related to eating and food preparation were measured because they have been shown to be related to eating behaviour in older adults and protein intake specifically (Appleton, 2016; Best & Appleton, 2013; Kremer, Bult, et al., 2007; Steptoe et al., 1995). Additionally, a validated questionnaire to measure ‘food neophobia’ was included as a measure of willingness to try new foods (Pliner & Hobden, 1992). It has been suggested that food neophobia may increase with age (Meiselman et al., 2010; Tuorila et al., 2001). If older adults are less willing to try new foods, this may be a barrier to try the recipes in the intervention. Additionally, a validated questionnaire was added to assess whether participants show symptoms of sarcopenia (Malmstrom & Morley, 2013). Chapter 4, and

Appleton (2016) show that the above demographic characteristics can predict egg and protein intake in older adults.

Reasons for eating or not eating eggs

Lastly, participants were asked to fill out a questionnaire about reasons for eating or not eating eggs. For this the questionnaire items from a previous study are used (chapter 4), which are based on reasons derived through a focus group study with a sample in the same target age group (chapter 3). These were included because the reasons people have for eating eggs, may give insight into the likelihood of participants increasing their egg intake or not. Chapter 4 shows that the reasons for eating eggs can predict egg intake in older adults.

Recipe feedback forms

Following the second and third test sessions (T2 and T3), the intervention group participants received a short questionnaire about the recipes. They were asked to comment on which recipes and herb/spice packets they used or did not use, and why. Recipe feedback forms were sent by post after the second test session, so that the completion of these does not impact on the primary measures. A freepost address was provided so the questionnaires could be returned to another researcher not in direct contact with participants (PhD supervisor). After all the data were collected, these were opened by the researcher. At T3 feedback forms were filled in by the participants at the end of the third test session before debriefing them. A copy of the recipe feedback form can be found in appendix 5.5. The responses on the recipe feedback forms are assessed in chapter 6.

Ethical approval for this study was granted by the Research Ethics Committee of Bournemouth University. All participants provided written informed consent, and the study was in line with the ethical considerations of the Declaration of Helsinki and the British Psychology Society Code of Ethics and Conduct (BPS, 2006). CONSORT guidelines were used to design and report the study (CONSORT, 2010). Participant recruitment started in May 2016, and test sessions were run from June 2016 to April 2017. The study is registered at ClinicalTrials.gov in May 2016 (NCT02777918).

5.2.13. Data analyses

Data was analysed using IBM SPSS Statistics for Windows, version 22. Amonk, NY: IBM Corp., using the 'intention to treat' approach. Data are reported as means and standard deviations. Participant characteristics and baseline measures were tested for normality, and compared between the intervention and control group using χ^2 tests and Mann-Whitney U tests. Correlations were reported between the baseline measures: age, BMI, fat percentage, lean body mass, handgrip strength, SPPB score, egg intake, protein intake, energy intake, HR QoL, and physical activity. Wilcoxon signed rank tests were used to compare the outcome variables (egg intake, protein intake, animal protein intake, lean body mass, handgrip strength, SPPB score, leg extensions, adverse effects, BMI, HR QoL, physical activity, and energy intake) between each test session (T1 and T2 and T3). Non parametric tests were used, because they are thought to be more conservative and less prone to disruption due to outliers and large variance (Mulhern & Greer, 2011). Although the non-parametric analyses are based on medians, the means are reported so they could be used to interpret the regression analyses. Multiple linear regressions were used for the main analyses. These analyses are parametric, but they are believed to be robust and appropriate with the sample size of this study. The effect of the intervention on different T2 measures was assessed using multiple linear regression, controlling for age, gender, baseline measures of the dependent variable, previous participation, and T2 measures of total protein intake, BMI, HR QoL, and physical activity. Separate regression models were used to predict egg intake, protein intake, animal protein intake, lean body mass, physical performance, handgrip strength, leg extensions, and adverse effects as the dependent variables. For example, multiple linear regression was used to assess whether egg intake at T2, could be predicted by the condition (intervention/control), age, gender, egg intake at T1, total protein intake at T2, BMI at T2, HR QoL at T2, physical activity at T2, and previous participation in the focus group study. The same analyses were also conducted for the same dependent variables at T3, including the measures of total protein intake, BMI, HR QoL, and physical activity at T3. Regression models predicting protein intake did not include follow up protein intake as an independent variable, only baseline protein intake. Egg intakes from two different measures were compared using correlations and multiple linear regressions were reported for both measures.

5.3 Results

5.3.1 Participant characteristics

A total of 100 participants took part, including 54 females and 46 males; mean age at baseline was 70 ± 7 years old, range 55-97 years old, mean BMI was 27 ± 4 kg/m^2. All participants were from countries that consume traditional western diets (97% were British, 1% was American, 1% was German, 1% was Dutch). Mean education was 15 ± 3 years, and most participants' most recent employment level was 'professional / management' (57%).Most participants did not wear dentures (84%), and most participants did not receive help with food shopping or preparing (95%). More information about participants characteristics can be found in table 5.1.

Participant characteristics group comparisons

Following randomization, 53 participants were allocated to the intervention group, 47 participants were allocated to the control group. For more information about the participants characteristics, please refer to table 5.1. There were no significant differences between the baseline measures for the intervention group and the control group for most variables, except for getting food delivered ($\chi^2 = 16.36$, $p < .01$), and sarcopenia prevalence based on the sarcopenia screening tool ($\chi^2 = 4.35$, $p < .05$).

Adherence

A total of 93 participants completed all three sessions of the study. Five participants dropped out of the study after T1, for reasons not related to the intervention (for medical reasons (n=3), or being stressed/too busy to come for the sessions and do the questionnaires (n=2)). One participant missed T2, but came back for the T3 session. One participant dropped out after T2. There were three drop outs in the intervention group, and four in the control group, this was not significantly different.

Two additional participants did all three test sessions, but suffered a medical condition affecting their diet and ability to change their diet in between the test sessions. They were treated like drop outs after T1 for the intention to treat analyses.

One individual completed all the measures for three test sessions but all questionnaire based measures were excluded from data analyses for exceptionally high reporting of egg intake (about 15 eggs/day).

Blinding of the researcher was broken by some participants during the trial (n=14). These incidences were recorded. There were no significant differences between the intervention group participants who broke the blinding and those who did not for the measures taken by the researcher after the blinding was broken.

Table 5.1 Participant characteristics (N = 100). Measures are reported as frequencies or Mean ± SD. Variables with significant differences between groups are in bold.*

	Total sample (N = 100)	Intervention group (n = 53)	Control group (n = 47)
Gender			
female	54	30	24
male	46	23	23
Education in years (Mean ± SD)	15 ± 3	15 ± 3	15 ± 3
Marital status			
Married	66	33	33
Divorced	19	10	9
Widowed	8	6	2
Never married	7	4	3
Living status			
Alone	30	17	13
With others	70	36	34
Most recent employment level			
Unemployed	2	1	1
Manual worker	10	4	6
Non-manual worker	29	15	14
Professional/Management	57	32	25
Vegetarian/pescatarian/vegan			
No	95	50	45
Yes	5	3	2
Denture wearing			
No	84	45	39
Partial dentures	13	5	8
Full dentures	3	3	0
Receiving help with food shopping			
Never	95	51	44
Sometimes	3	1	2
Often	1	1	0
Receiving help with food preparing			
Never	95	51	44
Sometimes	4	2	2
Often	0	0	0
Eating out or away from home			
Never	2	1	1
Sometimes	74	38	36
Often	23	13	10
Getting food delivered**			
Never	85	**42**	**43**
Sometimes	13	**10**	**3**
Often	0	**0**	**0**
Food Neophobia (Mean + SD)	22 + 7	22 + 7	22 + 7
Sarcopenia prevalence (screening tool score)***	4 (4%)	**3 (6%)**	**1 (2%)**

* For some variables the sample is not complete to because a few participants left a question open.
** Chi squared test showed a significant difference between the intervention and control group (p<.01)
*** Chi squared test showed a significant difference between the intervention and control group (p<.05)

Table 5.2 Prevalence scores for sarcopenia (based on handgrip strength), egg consumption and protein intake (N = 100) Variables with significant differences between groups are in bold.

	Total sample (N = 100)	Intervention group (n = 53)	Control group (n = 47)
Sarcopania prevalence (handgrip strength)*	9 (9%)	**7 (13%)**	**2 (4%)**
Participants who do not eat eggs	4 (4%)	2 (4%)	2 (4%)
Participants who eat more than 12 eggs/month	63 (63%)	32 (60%)	31 (66%)
Participants with protein intake under 0.8g/kg/day	14 (14%)	6 (11%)	8 (17%)
Participants with protein intake under 1.2g/kg/day	50 (50%)	28 (53%)	22 (47%)

* Chi squared test showed a significant difference between the intervention and control group ($p < .01$)

Table 5.3 Baseline measures for the intervention and control group. All measures are reported as Mean ± SD. Variables with significant differences between groups are in bold.

	Total sample (N = 100)	Intervention group (n = 53)	Control group (n = 47)
Age in years	70 ± 7	70 ± 8	70 ± 7
BMI in kg/m^2	26.64 ± 4.34	26.98 ± 4.18	26.26 ± 4.53
Fat percentage of total body weight	33.11 ± 8.66	33.86 ± 8.78	32.27 ± 8.54
Lean body mass in g	50.42 ± 12.68	50.36 ± 12.68	50.49 ± 12.81
Handgrip strength in kg	32.61 + 10.00	31.58 ± 10.51	33.78 ± 9.36
SPPB score (0-12)*	8.52 ± 2.37	**7.81 ± 2.34**	**9.32 ± 2.16**
Egg intake per month	22 ± 16	23 ± 17	21 ± 15
Protein intake per day in g	92 ± 32	93 ± 30	91 ± 33
Protein intake in g/kg body weight	1.26 ± 0.46	1.25 ± 0.43	1.27 ± 0.49
Energy intake in kcal	2187 ± 755	2195 ± 686	2179 ± 834
HR QoL score**	684 ± 131	681 ± 138	687 ± 123
Physical activity in kcal/week***	4318 ± 3042	4199 ± 3122	4456 ± 2976

* Mann Whitney U test showed a significant difference between the intervention and control group (p=.002)
**Health related quality of life was measured by the SF36 questionnaire.
***Physical activity was measured by the CHAMPS questionnaire.

5.3.2 Baseline measures

Table 5.2 shows that 4% of all participants did not eat eggs, and that 63% reported to eat more than 12 eggs per month. Of all participants, 14% did not meet the dietary protein intake recommendation of 0.8 g/kg of body weight/day, and 50% of the total sample did not meet the suggested higher protein intake recommendation for older adults of 1.2 g/kg/day. There was a significant difference between the groups in sarcopenia prevalence based on handgrip strength ($\chi^2 = 12.52$, $p < .01$). All baseline measures for the total sample, and the intervention group and the control group, can be found in table 5.3. Mann Whitney tests were used to compare the baseline measures for the intervention group and the control group. Of all variables, only one measure showed a significant difference. SPPB score (range 0-

12) was significantly different between the two groups (U = 1692.5, z = 3.11, p = .002) with 7.81 ± 2.34 for the intervention group, and 9.32 ± 2.16 for the control group. Normality tests for baseline measures can be found in appendix 5.6.

Correlations between baseline measures

Spearman correlations between the baseline data show that egg intake was significantly correlated with physical activity (r = .205, p = .042), intake of protein (r = .355, p < .001), and energy (r = .301, p = .002). Protein intake is significantly correlated with intake of energy (r = .932, p < .001). Age was significantly correlated with SPPB score (r = -.429, p < .001), and HR QoL (r = -.216, p = .032). BMI was significantly correlated with lean body mass (r = .404, p < .001), leg extensions (r = .311, p = .002), and physical activity (r = -.203, p = .044). Lean body mass was significantly correlated with handgrip strength (r = .801, p < .001), leg extensions (r = .258, p = .010), physical activity (r = .273, p = .006), and energy intake (r = .203, p = .043). Handgrip strength was significantly correlated with leg extensions (r = .227, p = .024), and physical activity (r = .236, p = .019). SPPB score was significantly correlated with HR QoL (r = .453, p < .001). More information can be found in appendix 5.7.

5.3.3 Egg intake

As can be seen in figures 5.2, and table 5.4, the intervention group mean egg intake was 23 ± 17 eggs at T1, and the control group mean egg intake was 21 ± 15 eggs at T1. The intervention group and the control group both significantly increase egg intake from T1 to T2, to 28 ± 20 eggs (T = 712, p = .028) and 25 ± 20 eggs (T = 641, p = .018) respectively. Egg intake for the control group is lower at T3 and not significantly different from T1 (22 ± 15 eggs). In the intervention group the mean egg intake at T3 remains different from T1 (T = 694, p = .046) with 27 ± 22 eggs.

Table 5.4 Means and standard deviations for all measures per group per time point. Measures are reported as Mean ± SD.

	Intervention group T1 (n = 53)	Intervention group T2 (n = 53)	Intervention group T3 (n = 53)	Wilcoxon rank test T1 - T2	Wilcoxon rank test T1 - T3
Egg intake (eggs/month)	23 ± 17	28 ± 20	27 ± 22	*p* = .028	*p* = .046
Protein intake (g/day)	93 ± 30	90 ± 29	86 ± 36		*p* = .038
Animal protein intake (g/day)	56 ± 20	55 ± 23	53 ± 24		
Lean body mass (g)	50.36 ± 12.68	50.25 ± 12.63	49.99 ± 12.58		
Handgrip strength (kg)	31.58 ± 10.51	32.37 ± 10.68	32.48 ± 9.93		*p* = .013
SPPB score (0-12)	7.81 ± 2.34	8.38 ± 2.56	8.40 ± 2.41	*p* = .047	
Leg extensions* (extensions)	32 ± 10	31 ± 11	33 ± 11		
Adverse effects (0-19)	1.08 ± 1.21	1.15 ± 1.86	1.36 ± 1.46		
BMI (kg/m^2)	26.98 ± 4.18	27.10 ± 4.05	27.33 ± 4.45	*p* = .025	*p* = .008
HR QoL score** (0-900)	681 ± 138	698 ± 134	696 ± 136		
Physical activity*** (kcal/week)	4199 ± 3122	3424 ± 2605	3902 ± 2606	*p* = .019	
Energy intake (kcal/day)	2195 ± 686	2132 ± 654	2021 ± 780		*p* = .009
	Control group T1 (n = 47)	Control group T2 (n = 47)	Control group T3 (n = 47)		
Egg intake per month (eggs)	21 ± 15	25 ± 20	22 ± 15	*p* = .018	
Protein intake (g/day)	91 ± 33	94 ± 35	90 ± 31		
Animal protein intake (g/day)	55 ± 21	59.± 25	54 ± 24		
Lean body mass (g)	50.49 ± 12.81	50.21 ± 12.76	50.12 ± 12.72		
Handgrip strength (kg)	33.78 ± 9.36	34.04 ± 9.65	33.60 ± 9.60		
SPPB score (0-12)	9.32 ± 2.16	9.13 ± 2.09	8.81 ± 2.26		*p* = .023
Leg extensions* (extensions)	29 ± 8	29 ± 10	30 ± 9		
Adverse effects (0-19)	0.72 ± 1.38	1.06 ± 1.26	1.19 ± 1.71		
BMI (kg/m^2)	26.26 ± 4.53	26.35 ± 4.31	26.50 ± 4.56		*p* = .011
HR QoL score** (0-900)	687 ± 123	703 ± 131	703 ± 131		
Physical activity*** (kcal/week)	4455 ± 2976	3570 ± 2303	3727 ± 2417	*p* = .002	*p* = .001
Energy intake (kcal/day)	2179 ± 834	2142 ± 741	2099 ± 654		

* Leg extensions are counted for different durations and using different ankle weights between participants. Mean values should be interpreted carefully.
**Self-perceived health was measured by the SF36 questionnaire.
***Physical activity was measured by the CHAMPS questionnaire.

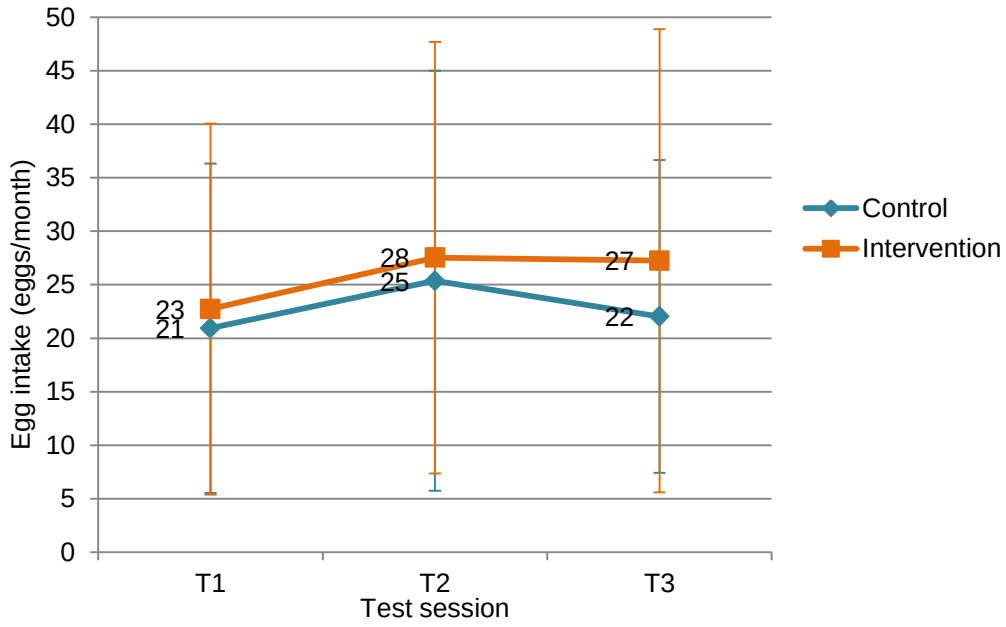

Figure 5.2 Egg intake for the control group and the intervention group at T1, T2 and T3. Error bars are standard deviations.

Predicting egg intake at T2

Egg intake at T2 was significantly predicted by the model (R = .816, R^2 = .666, adjusted R^2 = .632, F(9, 89) = 19.709, and p < .001). However, being in the intervention group or the control group did not predict intake of eggs at T2 (*Beta* = -.013, p = .835). Egg intake at T2 was significantly predicted by egg intake at T1 (*Beta* = .685, p < .001), protein intake at T2 (*Beta* = .200, p = .003), and BMI at T2 (*Beta* = .154, p = .020). Eating more eggs at T2 is related to eating more eggs at T1, eating more total protein at T2, and having a higher BMI at T2. The results are shown in table 5.5.

Predicting egg intake at T3

The model also significantly predicted egg intake at T3 (R = .820, R^2 = .673, adjusted R^2 = .640, F(9, 89) = 20.352, and p < .001). Intake of eggs at T3 was significantly predicted by the condition (*Beta* = -.124, p = .047), egg intake at T1 (*Beta* = .610, p < .001), protein intake at T3 (*Beta* = .322, p < .001), and age (*Beta* = .140, p = .035). Eating more eggs at T3 was significantly related to being in the intervention group (compared to the control group), eating more eggs at T1, eating more protein in total at T3, and being older. The results can be found in table 5.6.

Egg intake from the SCG FFQ

For the intervention group, T1 egg intake measured by the SCG FFQ was 16.20 ± 13.81, T2 egg intake was 18.28 ± 15.11, and T3 egg intake was 21.00 ± 19.45. For the control group, T1 egg intake was 15.41 ± 12.06, T2 egg intake was 17.09 ± 14.88, and T3 egg intake was 15.67 ± 12.58. It should be noted that the egg intake values from the SCG FFQ are lower than the values from the new scale. Although the egg intake mean values are different, the FFQ egg intake data correlates strongly with the egg intake measured by the new scale at all three time points (T1, $r = .773$, $p < .001$, T2, $r = .825$, $p < .001$, T3, $r = .819$, $p < .001$). Multiple linear regressions using the SCG FFQ egg intake data show egg intake at T2 can be significantly predicted by the model, $R = .829$, $R^2 = .687$, adjusted $R^2 = .656$, $F(9, 89) = 21.744$, and $p < .001$. Where higher egg intake at T2 is significantly predicted by higher egg intake at T1 (*Beta* = .700, $p < .001$), higher protein intake at T2 (*Beta* = .193, $p = .004$), and being a previous participant (*Beta* = .158, $p = .018$). Egg intake at T2 was not significantly predicted by the condition (*Beta* = -.037, $p = .536$). SCG FFQ egg intake at T3 was also significantly predicted by the model, $R = .817$, $R^2 = .667$, adjusted $R^2 = .633$, $F(9, 89) = 19.820$, and $p < .001$. Higher egg intake at T3 was significantly predicted by being in the intervention group (*Beta* = -.161, $p = .011$), higher egg intake at T1 (*Beta* = .634, $p < .001$), higher protein intake at T3 (*Beta* = .276, $p < .001$), higher BMI at T3 (*Beta* = .160, $p = .016$), lower physical activity at T3 (*Beta* = -.159, $p = .022$), and being a previous participant (*Beta* = .151, $p = .024$). Tables with all Beta and p values can be found in appendix 5.8.

5.3.4 Protein intake

Table 5.4 shows the mean values for all the measurements per test session per condition. It shows that protein intake (g) decreased for the intervention group from 93 ± 30g at T1, to 90 ± 29g at T2, and 86 ± 36g at T3, the decrease from T1 to T3 was significant (T = 368, $p = .038$). For the control group there were no significant differences in protein intake over time (91 ± 33g at T1, 94 ± 35g at T2, 90 ± 31g at T3). Animal protein intake did not change significantly over time for either group.

Predicting protein intake at T2

Results of the regression model of protein intake at T2 can be found in table 5.5. It shows that protein intake at T2 can be significantly predicted by the model, $R = .778$, $R^2 = .605$, adjusted $R^2 = .570$, $F(8, 90) = 17.226$, and $p < .001$. Being in the intervention group or the control group did not predict protein intake at T2 (*Beta* =

.071, *p* = .292). Protein intake at T1 significantly predicted protein intake at T2 (*Beta* = .749, *p* < .001), indicating that eating more protein at baseline was related to eating more protein at T2. Table 5.5 also shows that the model significantly predicts animal protein intake at T2, *R* = .713, R^2 = .508, adjusted R^2 = .464*, F*(8, 90) = 11.609, and *p* < .001. Being in the intervention or control group did not significantly predict animal protein intake. Higher animal protein intake at T1 was significantly related to higher animal protein intake at T2 (*Beta* = .681, p <.001).

Predicting protein intake at T3

Table 5.6 shows that the model for protein intake at T3 was significant, *R* = .720, R^2 = .519, adjusted R^2 = .476*, F*(8, 90) = 12.143, and *p* < .001. Intake of protein at T3 was not significantly predicted by being in the intervention/control group (*Beta* = .070, *p* = .348). Higher protein intake at T3 was significantly predicted by higher protein intake at T1 (*Beta* = .716, *p* < .001). The model predicting animal protein intake at T3 was also significant (*R* = .730, R^2 = .532, adjusted R^2 = .491*, F*(8, 90) = 12.807, and *p* < .001). Animal protein intake at T3 was not significantly related to condition (intervention/control), but it was related to higher animal protein intake at T1 (*Beta* = .718, *p* < .001), and lower physical activity at T3 (*Beta* = -.191, *p* = .018).

Table 5.5 Multiple linear regression results predicting egg intake, protein intake, animal protein intake, and adverse effects at T2.

	Egg intake at T2		Protein intake at T2		Animal protein intake at T2		Adverse effects at T2	
Regression model	R = .816, R^2 = .666, adjusted R^2 = .632, F(9, 89) = 19.709, and p < .001		R = .778, R^2 = .605, adjusted R^2 = .570, F(8, 90) = 17.226, and p < .001		R = .713, R^2 = .508, adjusted R^2 = .464, F(8, 90) = 11.609, and p < .001		R = .600, R^2 = .360, adjusted R^2 = .295, F(9, 89) = 5.564, and p < .001	
	Beta	*p*	*Beta*	*p*	*Beta*	*p*	*Beta*	*p*
Condition (intervention, control)	-.013	.835	.071	.292	.095	.208	.051	.558
Age (years)	.013	.841	-.031	.668	-.019	.811	-.097	.292
Gender (female, male)	.017	.799	.093	.207	.072	.384	-.125	.191
Egg intake at T1 (eggs/month)	**.685**	**.000**						
Protein intake at T1 (g/day)			**.749**	**.000**				
Animal protein intake at T1 (g/day)					**.681**	**.000**		
Adverse effects at T1							**.409**	**.000**
Protein intake at T2 (g/day)	**.200**	**.003**					.037	.677
BMI atT2 (kg/m2)	**.154**	**.020**	-.028	.690	.024	.758	.141	.125
HR QoL score at T2*	-.098	.147	-.088	.220	-.110	.169	-.192	.051
Physical activity at T2 (kcal) **	-.012	.863	-.094	.197	-.067	.406	.062	.510
Previous participant (no, yes)	-.019	.786	.109	.133	.065	.425	-.043	.650

*Health related quality of life was measured by the SF36 questionnaire.
**Physical activity was measured by the CHAMPS questionnaire.

Table 5.6 Multiple linear regression results predicting egg intake, protein intake, animal protein intake, and adverse effects at T3

	Egg intake at T3		Protein intake at T3		Animal protein intake at T3		Adverse effects at T3	
Regression model	R = .820, R^2 = .673, adjusted R^2 = .640, F(9, 89) = 20.352, and p < .001		R = .720, R^2 = .519, adjusted R^2 = .476, F(8, 90) = 12.143, and p < .001		R = .730, R^2 = .532, adjusted R^2 = .491, F(8, 90) = 12.807, and p < .001		R = .603, R^2 = .364, adjusted R^2 = .299, F(9, 89) = 5.650, and p < .001	
	Beta	*p*	*Beta*	*p*	*Beta*	*p*	*Beta*	*p*
Condition (intervention, control)	**-.124**	**.047**	.070	.348	.006	.935	-.006	.941
Age (years)	**.140**	**.035**	-.001	.989	-.015	.843	-.011	.902
Gender (female, male)	-.027	.691	.097	.231	.091	.253	-.070	.456
Egg intake at T1 (eggs/month)	**.610**	**.000**						
Protein intake at T1 (g/day)			**.716**	**.000**				
Animal protein intake at T1 (g/day)					**.718**	**.000**		
Adverse effects at T1							**.408**	**.000**
Protein intake at T3 (g/day)	**.322**	**.000**					.141	.103
BMI atT3 (kg/m2)	.079	.228	-.038	.625	-.029	.711	.099	.283
HR QoL score at T3*	-.070	.294	-.066	.400	-.099	.204	**-.196**	**.045**
Physical activity at T3 (kcal) **	.025	.712	-.081	.314	**-.191**	**.018**	-.098	.288
Previous participant (no, yes)	.130	.052	-.002	.984	.087	.268	.177	.056

*Health related quality of life was measured by the SF36 questionnaire.
**Physical activity was measured by the CHAMPS questionnaire.

5.3.5 Lean body mass, physical abilities, and muscle strength

Mean values for lean body mass and other aspects of body composition, physical performance and -strength are shown in table 5.4. Gender specific mean values can be found in appendix 5.9. Lean body mass for both groups did not show significant differences. The SPPB scores significantly increase for the intervention group only from 7.81 ± 2.34 at T1 to 8.38 ± 2.56 at T2 (T = 389, p = .047, r = .20), and significantly decrease for the control group from 9.32 ± 2.16 at T1 to 8.81 ± 2.26 at T3 (T = 124.5, p = .023, r = -.23). Handgrip strength did not change significantly over time for the control group, and significantly increased from 31.58 ± 10.51kg at T1 to 32.48 ± 9.93kg at T3 in the intervention group (T = 863, p = .013, r = .25). There were no significant differences in leg extensions.

Predicting lean body mass, physical performance and muscle strength at T2

The outcomes of the different multiple linear regression models predicting the dependent variables lean body mass, physical performance and hand grip strength at T2 can be found in table 5.7. Lean body mass at T2 was significantly predicted by the multiple linear regression model (R = .995, R^2 = .989, adjusted R^2 = .988, F(9, 88) = 917.797, and p < .001). The condition (intervention or control group) did not predict lean body mass at T2 (*Beta* = -.003, p = .809). A higher lean body mass at T2 was significantly related to being male (*Beta* = .050, p = .031), a higher lean body mass at T1 (*Beta* = .934, p < .001), and a higher BMI at T2 (*Beta* = .050, p < .001). Physical performance (SPPB) score at T2 was also significantly predicted by the model, R = .831, R^2 = .691, adjusted R^2 = .660, F(9, 89) = 22.129, and p < .001. The condition (intervention or control group) did not predict physical performance at T2 (*Beta* = -.056, p = .386). A higher SPPB score at T2 was significantly predicted by lower age (*Beta* = -.187, p = .008), higher SPPB score at T1 (*Beta* = .650, p < .001), and higher physical activity at T2 (*Beta* = .223, p = .001). Handgrip strength at T2 was significantly predicted by the regression model (R = .968, R^2 = .937, adjusted R^2 = .930, F(9, 89) = 146.511, and p < .001). Being in the intervention group or the control group did not predict handgrip strength at T2 (*Beta* = -.015, p = .583).Higher handgrip strength at T2 was significantly related to being male (*Beta* = .145, p = .001), and higher handgrip strength at T1 (*Beta* = .861, p < .001). Number of leg extensions at T2 was significantly predicted by the regression model (R = .750, R^2 = .562, adjusted R^2 = .515, F(9, 85) = 12.106, and p < .001). Number of leg extensions at T2 was not significantly predicted by being in the intervention group or the control group (*Beta* = -.034, p = .642). Higher numbers of leg extensions at T2

was significantly related to higher numbers of leg extensions at T1 (*Beta* = .725, $p < .001$).

Predicting lean body mass, physical performance and muscle strength at T3

Table 5.8 shows the results of the different multiple linear regression models predicting the dependent variables lean body mass, physical performance and hand grip strength at T3. The multiple linear regression model significantly predicted lean body mass at T3, $R = .992$, $R^2 = .985$, adjusted $R^2 = .983$, $F(9, 89) = 646.364$, and $p < .001$. Being in the intervention group or the control group did not significantly predict lean body mass at T3 (*Beta* = -.002, $p = .907$). Higher lean body mass at T1 was a significantly related to higher lean body mass at T3 (*Beta* = .948, $p < .001$). Physical performance (SPPB) score at T3 was also significantly predicted by the regression model ($R = .808$, $R^2 = .652$, adjusted $R^2 = .617$, $F(9, 89) = 18.541$, and $p < .001$). Being in the intervention group or the control group did not significantly predict physical performance at T3 (*Beta* = -.106, $p = .120$).A higher physical performance score at T3 was significantly related to younger age (*Beta* = -.151, $p = .043$), higher SPPB score at T1 (*Beta* = .571, $p < .001$), lower BMI at T3 (*Beta* = -.210, $p = .002$), higher HR QoL at T3 (*Beta* = .164, $p = .023$), and higher physical activity at T3 (*Beta* = .255, $p < .001$). Handgrip strength at T3 was significantly predicted by the model as well ($R = .966$, $R^2 = .934$, adjusted $R^2 = .927$, $F(9, 89) = 138.873$, and $p < .001$). Handgrip strength at T3 was not significantly predicted by the condition (intervention/control) (*Beta* = -.040, $p = .152$). Greater handgrip strength at T3 was significantly predicted by being male (*Beta* = .161, $p < .001$), and higher handgrip strength at T1 (*Beta* = .849, $p < .001$). Lastly, leg extensions at T3 was significantly predicted by the multiple linear regression model as well ($R = .699$, $R^2 = .488$, adjusted $R^2 = .433$, $F(9, 83) = 8.796$, and $p < .001$). The number of leg extensions at T3 were not significantly predicted by being in the intervention or control group (*Beta* = -.074, $p = .360$). A higher number of leg extensions at T3 was significantly predicted by higher number of leg extensions at T1 (*Beta* = .622, $p < .001$), and higher protein intake (*Beta* = .170, $p = .037$).

Table 5.7 Multiple linear regression results predicting lean body mass, physical performance, handgrip strength, and leg extensions at T2.

	Lean body mass at T2		Physical performance (SPPB) score at T2		Handgrip strength at T2		Leg extensions at T2	
Regression model	R = .995, R^2 = .989, adjusted R^2 = .988, F(9, 88) = 917.797, and p < .001		R = .831, R^2 = .691, adjusted R^2 = .660, F(9, 89) = 22.129, and p < .001		R = .968, R^2 = .937, adjusted R^2 = .930, F(9, 89) = 146.511, and p < .001		R = .750, R^2 = .562, adjusted R^2 = .515, F(9, 85) = 12.106, and p < .001	
	Beta	*p*	*Beta*	*p*	*Beta*	*p*	*Beta*	*p*
Condition (intervention, control)	-.003	.809	-.056	.386	-.015	.583	-.034	.642
Age (years)	-.018	.166	**-.187**	**.008**	-.053	.073	-.001	.993
Gender (female, male)	**.050**	**.031**	-.025	.705	**.145**	**.001**	.023	.776
Lean body mass at T1 (kg)	**.934**	**.000**						
SPPB score at T1			**.650**	**.000**				
Handgrip strength at T1 (kg)					**.861**	**.000**		
Leg extensions at T1							**.725**	**.000**
Protein intake at T2 (g/day)	-.021	.069	-.022	.720	-.053	.058	-.014	.847
BMI at T2 (kg/m2)	**.050**	**.000**	-.068	.279	.025	.388	-.062	.418
HR QoL score at T2*	.003	.769	.125	.065	-.032	.269	-.072	.355
Physical activity at T2 (kcal) **	-.004	.771	**.223**	**.001**	-.005	.877	.098	.219
Previous participant (no, yes)	-.002	.869	-.070	.287	-.004	.891	-.037	.637

*Health related quality of life was measured by the SF36 questionnaire.
**Physical activity was measured by the CHAMPS questionnaire.

Table 5.8 Multiple linear regression results predicting lean body mass, physical performance, handgrip strength, and leg extensions at T3.

	Lean body mass at T3		Physical performance (SPPB) score at T3		Handgrip strength at T3		Leg extensions at T3	
Regression model	R = .992, R^2 = .985, adjusted R^2 = .983, F(9, 89) = 646.364, and p < .001		R = .808, R^2 = .652, adjusted R^2 = .617, F(9, 89) = 18.541, and p < .001		R = .966, R^2 = .934, adjusted R^2 = .927, F(9, 89) = 138.873, and p < .001		R = .699, R^2 = .488, adjusted R^2 = .433, F(9, 83) = 8.796, and p < .001	
	Beta	*p*	*Beta*	*p*	*Beta*	*p*	*Beta*	*p*
Condition (intervention, control)	-.002	.907	-.106	.120	-.040	.152	-.074	.360
Age (years)	-.028	.069	**-.151**	**.043**	-.038	.206	.005	.954
Gender (female, male)	.047	.084	-.114	.104	**.161**	**.000**	.043	.632
Lean body mass at T1 (kg)	**.948**	**.000**						
SPPB score at T1			**.571**	**.000**				
Handgrip strength at T1 (kg)					**.849**	**.000**		
Leg extensions at T1							**.622**	**.000**
Protein intake at T3 (g/day)	-.006	.672	.076	.232	-.037	.191	**.170**	**.037**
BMI atT3 (kg/m2)	.002	.886	**-.210**	**.002**	.021	.478	-.089	.296
HR QoL score at T3*	.019	.183	**.164**	**.023**	-.010	.726	-.091	.287
Physical activity at T3 (kcal) **	-.001	.948	**.255**	**.000**	-.014	.652	.156	.078
Previous participant (no, yes)	-.007	.636	-.012	.858	-.010	.730	-.026	.759

*Health related quality of life was measured by the SF36 questionnaire.
**Physical activity was measured by the CHAMPS questionnaire.

5.3.6 Adverse effects

Table 5.5 shows that the multiple linear regression model for adverse effects at T2 was significant, $R = .600$, $R^2 = .360$, adjusted $R^2 = .295$, $F(9, 89) = 5.564$, and $p < .001$. Adverse effects at T2 was not significantly predicted by being in the intervention group or the control group (*Beta* = .051, $p = .558$). A higher number of adverse effects at T2 was significantly predicted by more adverse effects at T1 (*Beta* = .409, $p < .001$). The model for adverse effects at T3 was also significant, $R = .603$, $R^2 = .364$, adjusted $R^2 = .299$, $F(9, 89) = 5.650$, and $p < .001$ (see table 5.6). Being in the intervention or control group did not predict adverse effects at T3 (*Beta* = -.006, $p = .941$). A higher number of adverse effects at T3 was significantly predicted by a higher number of adverse effects at T1 (*Beta* = .408, $p < .001$), and a lower HR QoL score (*Beta* = -.196, $p = .045$).

5.4 Discussion

This study aimed to increase egg intake, and protein intake, in community dwelling individuals aged over 55 years old, by providing recipes and complementary herb/spice packets to increase the flavour and variety of egg dishes. The following sections will discuss the results on egg intake, protein intake, muscle mass and function, and the strengths and limitations of this study.

5.4.1 Egg intake

For this study the intervention group received recipes of egg based dishes, and were hypothesized to increase their egg intake. The control group participants did not receive the recipes, and were expected to continue their usual diet and not change their egg intake during the study. Egg intake was not significantly different between the intervention and control group at baseline, and from T1 to T2 being in the intervention or control group did not differ in egg intake in the multiple linear regression. However, at T3 regression analysis showed that being in the intervention group was significantly related to higher egg intake.

This indicates that after the intervention and the follow up period, but not directly after the intervention period, egg intake for those who received the recipes was higher than the control group. This suggests that participants kept the recipes and have used them after they stopped receiving the recipes (the intervention period). If older adults keep recipes and keep using them, this could mean they may do this

with recipe cards from supermarkets, or recipes in magazines. For UK adults, using recipes from magazine and newspaper articles is one of the three main sources to learn about cooking (together with cookbooks and cooking programs on television) (Caraher et al., 2000). The use of recipe cards on longer term may be encouraged by making them hardwearing, and by providing a way to store them. For example, a simple binder may encourage more people to keep them, and make it easier to re-use the recipes. The current research results show that exposure to recipes can change the eating behaviour of older adults. Cooking shows on television are very popular, and attract a high percentage of middle aged and elderly population, and the sales of cooking magazines and books are increasing (Caraher, Dixon, Lang, & Carr-Hill, 1999; Caraher et al., 2000). Promoting recipes that would be beneficial for older adults may therefore reach a large amount of people.

Mean values show that both groups increased egg intake from T1 to T2, which may explain why there is no effect of condition at T2. The unexpected increase in egg intake at T2 for the control group may be seasonal, although the T2 sessions were between September and December and it is unsure why egg intake would be higher during that period. It could also be a result of taking part in a study. Although participants were not told the study was about eggs, they received extra questions about eggs, which may have made them think they were expected to increase egg intake. Demand characteristics or uninstructed changes in lifestyle are common in health related intervention studies, where just taking part in a study can make participants eat/behave differently than they would usually do (Betts et al., 2014; Faith, Wong, & Allison, 1998; Robinson et al., 2015). Another explanation for the increased egg intake in all participants could be the dietary information post card. Every participant received a postcard with a short message about the importance of protein for older adults. This was done to increase the relevance of the high protein recipes for the intervention group. Because most nutrition education interventions with older adults show limited success in changing behaviour (Sahyoun, Pratt, & Anderson, 2004), it was not expected to affect food intake in the control group three months after receiving the postcard. Participants were not asked whether they recall the postcard message, so it remains unsure whether this was influencing the results. There may have been other reasons that changed participants' eating behaviour temporarily, e.g. holidays, but after randomization this potential influence is expected to be similar in both groups.

The regression analyses showed that higher egg intake was related to higher egg intake at baseline and higher protein intake. Higher egg intake at T2 was related to higher BMI, and for egg intake at T3 was a positive significant predictor of age. Eating behaviour in older adults tends to be driven by habits and past eating behaviour (Edfors & Westergren, 2012; Falk et al., 1996), which may explain why the egg intake at T2 and at T3 is strongly related to egg intake at T1. Higher egg intake was positively related to higher protein intake, and associations between protein intake and egg intake have been shown before. Chapter 4 shows a strong relation between egg intake and protein intake frequency, and eggs have been associated with high intakes of processed and red meats in other studies (Hu, Stampfer, Rimm, et al., 1999; Ruxton et al., 2010). There are indications that egg intake is related to unhealthy lifestyle factors including physical inactivity, and unhealthy eating patterns including high intakes of SFA, and energy (Djoussé et al., 2009; Hu, Stampfer, Rimm, et al., 1999; Ruxton et al., 2010), which may explain the relation between higher egg intake and higher BMI at T2. Within the age range of the sample from 55 to 97 years old, higher age was associated with higher egg intake at T3. However, age was not related to egg intake at baseline or at T2. This indicates that at the test session after the intervention period as well as the follow up period, but not directly after the intervention, egg intake was higher in participants with higher age. If assuming that increased egg intake is related to use of the recipes, and the increase in egg intake from T1 to T3 may be greater with higher age, this suggests younger individuals within this age range may benefit more from a different approach. These results are unexpected because other studies show that with older age individuals tend to be less likely to try new recipes (Sidenvall, Nydahl, & Fjellström, 2001).

Mean egg intake at baseline was 22 eggs, which is higher than the NDNS data indicating that British older adults (65+) consume 33g of eggs and egg dishes per month (equivalent to up to 16-17 eggs). Moreover, the NDNS data of all adults (over 19 years old) show that about one third (32%) of the sample did not eat any eggs per week, about one third (34%) had less than three eggs per week, and about one third (34%) ate more than three eggs per week (Ruxton et al., 2010). A study with older adults living in Scotland even showed that 70-79% of the participants did not consume eggs or egg dishes; These elderly participants were all over 75 years old, interviewed in their own home and recruited through a general practitioner (McKie et al., 2000). In the current sample only 4% did not eat eggs at all, and 64% eats more than 12 eggs per month (or three eggs per week). The different age groups and

recruitment strategies may partly explain the difference, but it still seems that the sample of this study includes people with a relatively high egg intake. The difference with NDNS data may also be a result of the difference in methodology. The NDNS data are based on four day food diaries for daily intake (Bates et al., 2014), while in the current study an FFQ was measuring monthly intake over the previous two-three months. During the focus groups people mentioned eating eggs irregularly, e.g. when in a rush to go out, when they come home late and do not feel like cooking, or when the eggs are about to go off (chapter 3, section 3.3.2). If egg intake may be irregular on a daily or weekly basis, it could result in under- or over-reporting in food diaries. Notably, even comparing the two FFQ measures in this study suggests under- or over-reporting of egg intake. The SCG FFQ section on eggs converted to egg intake per month was lower than the new FFQ measure for egg intake that was designed for this PhD project, with 16 eggs compared to 22 eggs per month. Although the 16 eggs per month are closer to the NDNS data (Bates et al., 2014), the main data analyses were based on the newly created scale with the higher estimations of intake. The SCG FFQ is validated for the total nutrient intake, not for each individual section (Masson et al., 2003). The section on egg intake in the SCG FFQ consisted of only three questions, and does not include mixed egg dishes like quiche, which may under estimate intake of eggs (Djoussé, 2013). The new scale may, however, also be overestimating egg intake and this should be taken into account when interpreting the results. Under- or over reporting of eggs on the different types of questionnaires is not expected to be different for high or low consumers. The direction of the regression results are the same, and all the significant predictors in the main analyses are also significant in the SCG FFQ regression results, except for age. Please find the results of the multiple linear regression analyses in appendix 5.7.

5.4.2 Protein intake

One of the aims of the study was to increase protein intake, but the regression models show that protein intake was not different between the intervention and control condition at T2 or T3. Baseline daily protein intake was 92g or 1.26 g/kg/day, which is high compared to 69.8g in the NDNS data (Bates et al., 2014). This may be due to volunteer bias, because the older adults who were willing to participate were all relatively active and involved in social activities which have been related to higher diet quality (Bloom et al., 2016; Bloom et al., 2017). The protein intake values are similar to other research studies with community dwelling older adults (Berner et

al., 2013; Mamerow et al., 2014; Morton et al., 2017). Despite the high average intake of protein, 50% of the total sample does not meet the 1.2g/kg/day increased recommendation for older adults (Bauer et al., 2013), while 14% does not meet the current protein intake recommendation for all adults of 0.8g/kg/day (Joint, 2007). This implies that even in this sample with relatively high mean protein intake, a large proportion of the older adults may still benefit from increasing their protein intake.

Regression analyses did not show a difference between the intervention and control group, although the mean values for the intervention group seem to decrease. This may be a result of a decrease in energy intake. Protein intake correlates strongly with energy intake, and the intervention group significantly decreased energy intake from T1 to T3, while the control group did not change. As mentioned above, taking part in a study can decrease participants' intake (Robinson et al., 2015). The intervention group received the recipe sets every two weeks, and were therefore much more often reminded of taking part compared to the control group who were only contacted about the test sessions which were three months apart. Participants may think reducing energy intake is desirable or healthy (Hetherington & Burnett, 1994; Pelchat & Schaefer, 2000), while it was never the intention of the study to reduce energy intake. Protein intake at T2 and T3 was strongly predicted by baseline protein intake, like for egg intake this may show that eating behaviour tends to be habitual. As mentioned before, eating behaviour in older adults has been related to habits and past eating behaviour (Edfors & Westergren, 2012; Falk et al., 1996).

Higher animal protein intake was related to lower physical activity, while some studies have linked higher animal protein to unhealthy lifestyles including physical inactivity (Pounis et al., 2010), other studies showed animal protein is related to positive health outcomes in older adults (Hannan et al., 2000; Lord, Chaput, Aubertin-Leheudre, Labonté, & Dionne, 2007). Animal based proteins contain all essential amino acids and are considered high quality protein sources (van Vliet et al., 2015). Animal protein stimulates a higher net protein synthesis than a high plant protein diet (Pannemans et al., 1998). However, British older adults are likely to eat a traditional British diet high in processed meat (Hamer, McNaughton, Bates, & Mishra, 2010), which has been related to adverse health outcomes (Fretts et al., 2012; Micha, Wallace, & Mozaffarian, 2010), and may explain this specific relation. For this study the effects of different types of animal protein were not analysed separately.

The power calculation of the study was based on increasing protein intake from the NDNS intake of 69.8g to a daily intake of 82.5g, equivalent to three times the intake of 25-30g of protein. Although there was a lot of variation, the protein intake of participants at baseline was 92g. The assumption about daily protein intake on which the power calculation was based was wrong for this sample. The sample size is likely too small to find a representative protein intake. A larger sample size may decrease the variance and increase the statistical power of the analyses.

The difference in egg intake between the intervention and control group at T3 is assumed to be a result of using the high-protein egg-based recipes, but protein intake does not differ. This may suggest that the high protein meals are replacing meals that were already high in protein (but lower in eggs), or compensated for by a reduced protein intake during the rest of the day. Compensation following higher protein intake is limited in other studies with older adults (Appleton, 2017a; Giezenaar et al., 2015; Smoliner et al., 2008; Stelten et al., 2015), and older adults generally tend to compensate less than younger adults (Appleton et al., 2011; Rolls et al., 1995). This study did not measure protein distribution over the day, or whether other protein rich foods were replaced with eggs.

5.4.3 Muscle mass and function

When looking at the results for lean body mass, physical performance, handgrip strength and leg extensions, none of the regression models were significantly predicted by the condition (intervention/control). The hypothesized increase in these measures for the intervention group were based on the assumption that protein intake would be increased. Chapter 2 discussed that higher protein intake has been related to improved outcomes for muscle mass, strength and function (Bauer et al., 2013; Deutz et al., 2014; Murphy et al., 2016). Since protein intake was not different for the intervention and control group, it was unlikely the measures of muscle mass and function would be different between the groups following the intervention.

All five measures were significantly predicted by their baseline measure. Changes in these measures are often small and outcomes are therefore likely to be strongly related to the baseline value (e.g. (Komar et al., 2015)). Higher lean body mass at T2 and handgrip strength at T2 and T3 were significantly related to being male. There are obvious gender differences in handgrip strength and body composition

(mean values can be found in appendix 5.9). These gender differences are well known in the literature (Bassey & Harries, 1993; Cruz-Jentoft et al., 2010; Lauretani et al., 2003). Better physical performance was significantly related to lower age and higher physical activity levels at T2 and T3, this is also shown in other studies (Guralnik et al., 1994; Patel et al., 2006). For T3, higher SPPB scores are significantly related to lower BMI and higher HR QoL, which has been reported in other studies as well (Chmelo et al., 2015; Lang, Llewellyn, Alexander, & Melzer, 2008; Latham et al., 2008). Higher lean body mass is significantly related to higher BMI, but lean body mass is part of total body weight, and higher body weight is directly related to higher BMI. Leg extensions were significantly predicted by higher protein intake, independent of the intervention. The relation between protein intake and muscle strength has been shown before (Sahni et al., 2015), but is complex and depends on dose, timing and quality (Murphy et al., 2016; Phillips, 2017). This may explain why the other muscle strength and physical performance measures in this study were not statistically related to protein intake.

At baseline, SPPB scores were lower for the intervention group, and sarcopenia prevalence based on screening tool score as well as sarcopenia prevalence based on handgrip strength was higher. Participants with lower physical performance and/or sarcopenia may experience difficulties with food shopping or food preparation and could respond to the intervention differently (Morton et al., 2017). It is unclear whether this affected the results, and in which direction. Interestingly, the SPPB scores increase from T1 to T3 for the intervention group, while they decrease for the control group. The changes either way are about 0.5 points within the 0-12 range of possible scores, which can be interpreted as a (small) meaningful change (Kwon et al., 2009; Perera, Mody, Woodman, & Studenski, 2006). It is unclear whether this different direction of change in SPPB scores is affected by the difference in SPPB scores at baseline. There is no difference in follow up SPPB scores between the conditions in the multiple linear regression when baseline values are taken into account.

The decreased physical activity levels for both groups may be affected by seasonal effects. All participants started between June and September and finished between December and March. Older adults may be more active in the summer than in the winter (Uitenbroek, 1993). Physical activity is related to muscle mass, strength and function (Cruz-Jentoft et al., 2010; Goodpaster et al., 2008), and is included in the regression analyses to control for this.

Of the 100 participants at baseline only four (4%) had a sarcopenia screening tool score predictive of sarcopenia and poor health outcomes (Malmstrom & Morley, 2013). The prevalence of sarcopenia based on handgrip strength was higher, with nine participants (9%). This prevalence may still be low because of volunteer bias, because the participants were relatively healthy and strong. The estimated prevalence of sarcopenia in community dwelling populations has been reported to range from 1-29% (Cruz-Jentoft et al., 2014), but the prevalence is strongly affected by the diagnostic tools used (Beaudart et al., 2015). The prevalence in the current study, is similar to the estimated prevalence of 4.6-7.9% in community dwelling older adults in the UK (Patel et al., 2013).

5.4.4 Strengths and limitations

The study is designed to be set in a real life setting rather than a laboratory setting. Participants organised, prepared and consumed their meals at home and no food stuffs, other than recipes herbs and spices, were provided. If the recipes were appealing enough for the participants to want to try them, they would need to buy the ingredients or choose a recipe with ingredients they store 'in the cupboard'. The study was designed to be comparable to everyday life exposure to recipes, e.g. in advertisements, magazines, or supermarkets. This means the participants' intake is less likely affected by them feeling they are being watched (Robinson 2015), although the decrease in energy intake for the intervention group suggests eating behaviour may still have been affected by taking part in a study.

Participants in the intervention group had to buy the foods if they wanted to use the recipes. Price is the most important factor influencing British consumer product choice, reported as more important than factors including taste, familiarity, health, and ease of using (Office-for-National-Statistics, 2016). While this may differ between different age groups, price is still likely to be an important determinant of food choice in older adults (Locher et al., 2009). Having to buy the foods makes the study more realistic and similar to eating behaviour in everyday life. A difference in egg intake was found at T3 between the intervention group and the control group, which suggests the intervention changed the participants' eating behaviour despite the foods not being provided. The limitations of this real life approach are that the effects are small and the variation is high, use of the recipes was not controlled or even stimulated. Compared to studies where participants are instructed to take protein rich supplements daily (e.g. (Tieland, van de Rest, et al., 2012)), or are

provided with protein rich foods that they are asked to eat every day (Daly et al., 2014), providing recipes may be much less effective in increasing protein intake. Although those types of studies are effective in increasing protein intake, it may not last when the study stops and supplements are not provided anymore. If older adults choose to use the recipes and buy the ingredients they may be more likely to keep doing this after the study finished.

Another strength is the use of conventional foods that are high in protein instead of protein supplements or enriched foods. Studies have shown that intake of protein rich foods for older adults is strongly affected by familiarity, habit and past eating behaviour (Best & Appleton, 2013; Herrema, Westerman, van Dongen, Kudla, & Veltkamp, 2017). This was also shown for egg intake specifically in the outcomes of the other two studies. Eggs were referred to as a staple food, and participants mentioned eating eggs as a habit during the focus groups (chapter 3, section 3.3.2). One of the significant predictors of egg intake in the outcomes of the questionnaire study was the component labelled 'everyday type of food' including the reasons habit and staple food (chapter 4, section 4.3.3). Moreover, the data from the current study show that egg intake is strongly affected by egg intake at baseline. Eggs are familiar to most people (Smith & Gray, 2016), and are eaten habitually (Conrad et al., 2017). It has been shown that older adults prefer to eat conventional protein rich foods over protein enriched foods to increase protein intake (van der Zanden et al., 2014a). This underlines the relevance for the current project where the willingness to make changes in eating habits may be facilitated by using familiar foods, rather than introducing unfamiliar food products.

For this intervention study the data analyses were not focused on change scores or interactions with conditions and change over time, but instead predicted T3 outcomes while controlling for T1 measurements. Vickers and Altman discuss how this is the preferred analyses for controlled trials with baseline and follow up measurements (Vickers & Altman, 2001). Baseline values tend to be negatively correlated with change, i.e. individuals with low scores are more likely to improve more. Although the intake data was not different, the physical performance (SPPB) scores were different at baseline, and would therefore benefit from this type of data analysis.

Previous participation was included in the regression analyses, because the previous participants may have remembered the aim of the PhD project after

participating in the focus groups. The regression analysis showed a trend for previous participation predicting egg intake at T3, which could mean participants who had participated in previous studies of this PhD may be eating more eggs at T3, which may be explained by knowing this PhD project is focused on increasing egg intake in older adults.

The participants were not asked what they thought the purpose of the study was. Therefore it is unclear whether the results may be attributable to a response to demand characteristics of the study. This is a limitation of the study.

For the SF-36 questionnaire assessing self-reported HR QoL, the total scores have been used for data analyses. Although the scale is developed to measure nine domains as outcomes, the SF-36 total score has been increasingly reported in different research studies (Lins & Carvalho, 2016). Because the study sample size is too small to include eight more variables (a total of nine for just SF-36) in the regression models (Howell, 2012), a total sum score was used as an indication of overall quality of life.

Because dietary intake was measured using FFQs, the distribution of protein intake over the day is not known. FFQs were chosen because they measured monthly intake. As mentioned above, egg consumption may be irregular on a daily and weekly basis for some people, while it is assumed egg consumption may be more stable on a monthly basis. However, FFQs do not provide the times different foods are eaten. In the questionnaire study in chapter 4, a short FFQ was used with additional questions to tick which time of the day a specific food was eaten. From the responses it seemed that the questions were difficult or confusing for participants, and many participants left the questions open. For this reason the participants in the current study were not asked to fill in extra questions about the times specific foods were eaten. Because of this it is unknown for which and for how many meals participants were reaching the protein intake of 25-30g and whether the distribution changed.

Recruitment focused on different strategies including contacting older adults who have participated in previous research studies, through clubs and societies (e.g. university of the third age, rotary clubs, the Odd Fellows, bridge clubs, rambling groups, etc.), or by flyers and posters at local general practitioner’s offices, museums, and libraries. Because for this project the target age was adults 55 years

and over, it was expected that health status and lifestyle may differ between age groups within this age range. This could affect eating behaviour and response to the intervention. However, the assumption that lifestyle is related to age may not have been met. It should be noted that potential volunteer bias and the ways of recruitment may be a confounder. Most of the participants were involved in clubs and societies. Involvement with social and cognitive leisure activities in older adults is known to be related to better diet quality, and smaller declines in diet quality over time (Bloom et al., 2016). Moreover, social engagement can be an important influence on diet quality in older adults (Bloom et al., 2017). Being involved in clubs and societies encourages social engagement, and may explain why protein intake was relatively high compared to the NDNS data. Recruiting older adults who are not taking part in clubs and societies was attempted by distributing posters and flyers in general practitioner's offices, museums and libraries. Unfortunately not many older adults responded to those. Recruiting people who are less involved in social activities is challenging, but would lead to a more representative sample in terms of lifestyle, health status and diet quality. Although the socially active lifestyle of most participants in the intervention study may mean the participants were relatively healthier for their age may have confounded the results, there are still differences in lifestyles and health status found within the age range (e.g. with physical performance scores).

Randomisation of participants was stratified per ten year age group, and controlled for previous participation and couples, but not for friends/acquaintances. Some participants knew each other, and on a few occasions the researcher's blinding was broken as a result of participants talking to each other, and subsequently talking about friends to the researcher.

Another limitation of the study is that the participants' eating ability or quality of teeth was not measured. A question was included about denture wearing, assuming that wearing dentures may be related to struggling with eating foods of difficult to eat textures. It may however be that people have bad teeth, which limits them to eat certain foods (Hildebrandt et al., 1997), but do not wear dentures. For future research it would be important to ask this directly. Another aspect not measured as part of this study is culinary skills. The community dwelling participants were assumed to know basic level cooking. The recipes included ranged in difficulty and preparation time, with many recipes with preparation times of less than 10 min, including some that only needed to be put together and put in the microwave.

However it is possible that if a person does not cook, the recipes can be very daunting, or they may have not read the recipes assuming they would not know how to do it. Studies show that culinary skills or physical ability to cook can be a barrier to cooking meals or improving healthy eating and energy intake (Allaire et al., 1991; Hughes et al., 2004). Studies show that especially British men are more likely to lack confidence in cooking and less likely to cook a main meal regularly (Adams et al., 2015; Caraher et al., 1999), and often did not get cooking classes in schools (Caraher et al., 2000), but gender did not significantly predict egg intake in this study. To make it a real life approach, recipes were not personalised to culinary skills. Many people are exposed to recipes in magazines, in supermarkets, on television and on packages (De Solier, 2005; McKie & Wood, 1992; Villani et al., 2015), where the recipes may not be personalised, and people choose to read them or not. Tailoring of recipes to groups of people has shown to be more successful in changing eating behaviour than generic recipes (Clarke, Evans, & Hovy, 2011). Addressing specific recipes to specific target groups, e.g. 'easy to prepare' recipes to older adults with lower culinary skills, may catch the attention of individuals who would not read them otherwise. This could be considered for future research studies. If exposing older adults to protein rich egg based recipes could make them eat more eggs and more protein it could be a straightforward to implement cost effective strategy.

5.5 Conclusions

To conclude, the intervention was successful in increasing egg intake until three months after the intervention. Egg intake in the intervention group was not different from the control group directly after the intervention (at T2), but it was significantly different from the control group after the intervention and follow up period (at T3). Total protein intake was not predicted by being in the intervention group at T2 nor at T3. Changes in lean body mass, muscle strength and physical performance were not related to the intervention. Despite the lack of increase in protein intake, the significant increase in egg consumption shows that providing recipes and herb/spice packets to older adults can change their eating behaviour. This suggests that exposing older adults to recipes could be used as a strategy to change eating behaviour.

The next chapter (chapter 6) reports further analyses on the data collected during this study, to investigate how the participant characteristics and reasons for eating or not eating eggs are related to the participants' behaviour during and after the intervention, and explore feedback from participants about the intervention.

6. Exploring change in egg intake in the intervention group: exploratory further analyses

6.1 Introduction

The current chapter was aimed to explore the data collected in the randomized control trial described in chapter 5. The design of the intervention study described in chapter 5 was based on the outcomes of a questionnaire study (chapter 4), which was based on the results of a qualitative study (chapter 3). Chapter 5 describes how providing high protein egg based recipes resulted in a significant difference in egg intake after the intervention and follow up period (at T3) between the intervention group and the control group, with a higher egg intake for the intervention group. However the variance in egg intake was very high. The increases in mean egg intake are small and have large standard deviations, indicating there is a wide range in intake values between people. This suggests that individual differences may have influenced how they responded to the intervention. Therefore the differences between the participants who increased and those who did not increase egg intake were explored in this chapter.

Other studies have shown that compliance to intervention studies is affected by the participants' preferences and habits, and by aspects of the intervention (Herrema et al., 2017; Sahyoun et al., 2004; van Dongen et al., 2017). Moreover, social class, education level, and age have been associated with the different sources from which people learn about cooking (e.g. family members, partner, or cooking classes, cook books, cooking programmes on television, articles in magazines, and booklets from supermarkets) (Caraher et al., 2000). The elderly population is strongly heterogeneous, varying greatly in physiology as well as psychology, and researchers have identified segments of older adults with similar eating behaviour related characteristics (den Uijl et al., 2014; van der Zanden et al., 2014b). Different meals may appeal to different older adults depending on whether they are focussed on social experiences or on healthy nutrition, or whether they are "adventurous" in changing their eating patterns or more habitual (den Uijl, Jager, de Graaf, & Kremer, 2016; den Uijl et al., 2014). Moreover, older adults may suffer from several different levels of physical abilities and eating capabilities, which would affect their food choice and their ability to prepare food (Allaire et al., 1991; Best & Appleton, 2013).

Due to the exploratory nature of the analyses in this chapter there are no hypotheses about the outcomes. The analyses are based on exploring how the participants who increased their egg intake during the intervention period differ from the participants who decreased or did not change their egg intake during the intervention period. Additionally, the exploratory analyses are focussed on whether change in egg consumption over time in the intervention group participants is related to the demographic characteristics, lifestyle factors, baseline measures, and reasons for eating eggs. Lastly, the recipe feedback forms filled in by participants in the intervention group were reviewed to find different barriers and facilitators to using the recipes, and identify how the design of the study could improve for future research studies.

6.2 Methods

6.2.1 Participants and measured outcomes

For this chapter the data collected as part of the randomized controlled trial in chapter 5 was used for further analyses. Participants were invited to three test sessions, T1 represents the test session at baseline, T2 after the three month intervention period, and T3 after six months (including the three months intervention and three months follow up). For details about the different measures and the methodology for each measure, please read section 5.2.7-5.2.12. As mentioned in chapter 5, several participants dropped out after the first test session, but were included in the 'intention to treat' analyses. For the analyses in this chapter, they are not included. For generating the difference scores the values for different time points are needed.

6.2.2 Outcomes

Difference scores – egg intake

During the intervention study egg intake was measured at three time points (test sessions T1, T2 and T3) measuring number of eggs eaten per month using the egg food frequency questionnaire (FFQ). From these responses difference scores can be generated to represent the change in monthly egg intake between the different test sessions. For the analyses in this chapter the difference scores between T1 and

T2 (egg intake at T2 – egg intake at T1), and the difference scores between T2 and T3 (egg intake at T3 – egg intake at T2) were generated. Therefore, a negative difference score means that egg intake decreased, while a positive difference score means egg intake increased. The time between T1 and T2 is referred to as the 'intervention', while the time between T2 and T3 is referred to as the 'follow up'.

Increase group and no increase group – egg intake

Based on the difference scores, the participants were allocated to different groups. All participants with positive difference scores were assigned to the group 'increase', while the participants with no change (zero), or negative difference scores were grouped to 'no increase'. This was done for the difference scores from T1 to T2 and for T2 to T3. However, the people who increase from T1 toT2 do not necessarily increase from T2 to T3. Therefore both groups were split to have four groups in total: the increase-increase group, the increase-decrease group, the decrease-increase group, and the decrease-decrease group. These four groups are only used to visualise the data in a figure, they were not compared statistically because the numbers per group would be small.

Recipe feedback form

As mentioned in chapter 5, section 5.2.12, the intervention group participants received a short questionnaire about the recipes after the second and third test sessions (T2 and T3). They were asked to fill in closed questions on whether they had used the recipes and herb/spice packets or not, and if they used the recipes they were asked to indicate which recipes they used, when they mostly ate the dishes, and how often they ate the dishes. The form also included open questions on why they decided to use or not use the recipes, why they choose specific recipes, why they decided to use or not use the herb/spice packets, and if there is anything we could change about the recipes to encourage them and other people to prepare the dishes. The recipe feedback form can be found in appendix 5.5.

Participant characteristics

In the analyses the demographic characteristics and lifestyle factors are used. These were measured at baseline for each participant. The demographic characteristics and lifestyle factors include: gender, marital status, living status, education duration, employment level, being vegetarian, denture wearing, receiving help with food shopping, receiving help with food preparation, eating away from home, getting food delivered, sarcopenia score, food neophobia score. For the

correlations, education duration was kept as a continuous variable. The other variables were converted to binary variables if they were not already binary, so point-biserial correlations could be used. Answers were grouped semantically, and based on responses, with highest frequency of response as a separate group. For this marital status was converted to married or not married (Divorced/Widowed/Never married), level of employment to 'professional or management' or other (Unemployed/Manual/Non-manual), denture wearing to dentures or no dentures, help with food shopping to never or sometimes/often, eating away from home to often or never/sometimes, sarcopenia score to sarcopenic or non sarcopenic, food neophobia score to food neophobic or non-food neophobic.

Reasons for eating or not eating eggs

At baseline all participants filled in the statements based on the reasons for eating or not eating eggs. The components generated as described in chapter 4 were used to see how they relate to change in egg intake. Agreement scores are based on five-point scale from strongly disagree to strongly agree. For more information about the components or the questionnaire please see chapter 4.

6.2.3 Data analyses

Data was analysed using IBM SPSS Statistics for Windows, version 22. Amonk, NY: IBM Corp.. Data are reported as means and standard deviations for transparency, and are reported with the non-parametric tests even though the tests are based on median values. Participants were allocated to groups based on whether they increased their egg intake during the intervention period, or whether they decreased or did not change their egg intake during the intervention period. Participant characteristics (including baseline measures (age, Body Mass Index (BMI), fat percentage, lean body mass, handgrip strength, leg extensions, Short Physical Performance Battery (SPPB) score, egg intake, protein intake, energy intake, Health Related Quality of Life (HR QoL), and physical activity), demographic characteristics and lifestyle factors (gender, education, marital status, living status, employment level, vegetarianism, denture wearing, receiving help with food shopping/preparing, eating out, food delivery, food neophobia, sarcopenia, protein intake prevalence, and previous participation)), and reasons for eating and not eating eggs were compared between the participants in the intervention group who increased their egg intake, and those who did not increase their egg intake using Mann-Whitney U

tests and Fisher's exact tests. Pearson correlations and point-biserial correlations were conducted between the difference scores for change in egg intake and the participants' characteristics, and reasons for eating and not eating eggs. Lastly, responses from the recipe feedback forms were reported.

6.3 Results

6.3.1 Participant characteristics

Following randomisation, 53 participants were allocated to the intervention group. As described in section 5.3.1 of chapter 5, some participants did not complete all three sessions. Because the analyses for the current chapter do not use the 'intention to treat' analyses, the intervention group includes 49 participants for this chapter. One participant with incomplete data missed T3 and can therefore be included for the T1 to T2 analyses. Consequently, the intervention group consists of 49 participants for the T1 to T2 difference scores and 48 for the T2 to T3 difference scores.

6.3.2 Change in egg intake

Table 6.1 and 6.2 show the number of participants in the intervention group and mean intake for who increased egg intake from T1 to T2 and from T2 to T3, or did not change egg intake from T1 to T2 and from T2 to T3. The tables show that during both phases of the study, there were participants who increased and participants who did not increase egg intake. Mean egg intake for the participants who increased and the participants who did not increase for T1 to T2 and for T2 to T3 can also be found in figure 6.1. Because participants who increase from T1 to T2 do not necessarily increase from T2 to T3, four groups are presented.

Table 6.1 Number of people who increased and did not increase egg intake in the intervention group in number of people and percentages.

	difference T2-T1	difference T3-T2
No increase (n=49)	22 (45%)	29 (60%)
Increase (n=48)	27 (55%)	19 (40%)

Table 6.2 Change in egg intake for the people who decreased or increased egg intake in the intervention group in number of eggs per month (mean ± SD) and range of difference scores.

	difference T2-T1	difference T3-T2
No increase (n=49)	-6 ± 7 (-32 to 0)	-8 ± 8 (-28 to 0)
Increase (n=48)	15 ± 13 (1 to 56)	11 ± 11 (2 to 39)

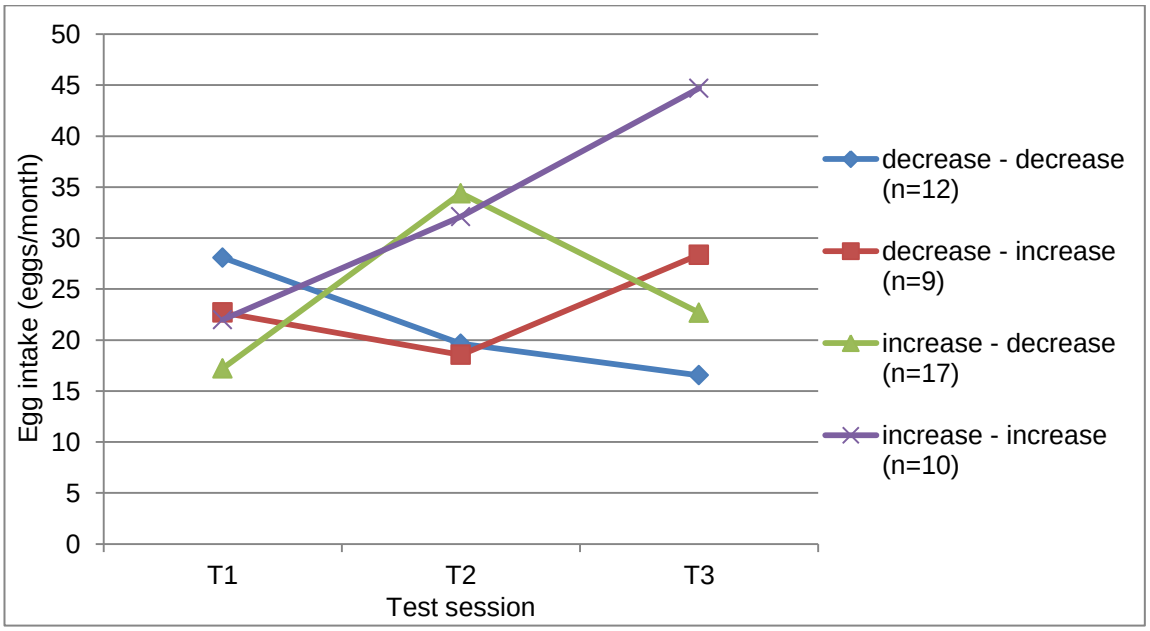

Figure 6.1 Change in egg consumption in the intervention group participants. Participants who increase egg intake from T1 to T2 are a combination of the 'increase – increase' group and the 'increase – decrease' group. The group of participants who do not increase egg intake from T1 to T2 are a combination of the 'decrease – increase' group and the 'decrease – decrease'. Those who increase from T2 to T3 are a combination of the 'decrease – increase' group and the 'increase – increase' group, while the participants who decrease egg consumption are a combination of the 'decrease – decrease' group and the 'increase – decrease' group. Decrease here includes participants who decrease egg intake and those who do not change intake.

6.3.3 Change in egg intake – group comparisons for participant characteristics

Non parametric tests were used, because most of the measures were not normally distributed at baseline (see Appendix 5.6). Table 6.3 shows that BMI was significantly different between the two groups for egg intake during the intervention period (U = 402.000, z = 2.111, p = .035). HR QoL was also significantly different for egg intake during the intervention period (U = 198.000, z = -1.990, p = .047).

Table 6.3 Intervention and control group baseline measures. Measures are reported as Mean ± SD.

	Intervention (T1 to T2)			Follow up (T2 to T3)		
	Increased egg intake (n = 27)	No increase egg intake (n = 22)	Mann-Whitney U Test	increased egg intake (n = 19)	No increase egg intake (n = 29)	Mann-Whitney U Test
Age in years	71 ± 9	68 ± 6		70 ± 10	70 ± 6	
BMI in kg/m^2	**28 ± 5**	**26 ± 3**	*p* = .035	26 ± 3	28 ± 5	
Fat percentage of total body weight	35 ± 9	32 ± 7		33 ± 9	34 ± 9	
Lean body mass in g	51 ± 14	51 ± 11		50 ± 14	51 ± 12	
Handgrip strength in kg	31 ± 9	33 ± 12		32 ± 10	32 ± 11	
Leg extensions	30 ± 9	30 ± 7		32 ± 9	29 ± 8	
SPPB score (0-12)	8 ± 2	8 ± 2		8 ± 2	8 ± 2	
Egg intake per month	19 ± 12	25 ± 20		22 ± 15	22 ± 16	
Protein intake in g	98 ± 33	90 ± 28		103 ± 29	90 ± 30	
Protein intake in g/kg	1.27 ± 0.44	1.25 ± 0.43		1.42 ± 0.42	1.18 ± 0.40	
Energy intake in kcal	2278 ± 771	2128 ± 592		2416 ± 776	2120 ± 584	
HR QoL score (0-900)	**658 ± 136**	**728 ± 117**	*p* = .047	697 ± 146	691 ± 121	
Physical activity (kcal/week)	4708 ± 3347	3577 ± 2369		4017 ± 2813	4333 ± 3167	

*HR QoL was measured by the SF36 questionnaire.
**Physical activity was measured by the Community Health Activities Model Program for Seniors (CHAMPS) questionnaire.

Table 6.4 shows the frequencies in demographic characteristics and lifestyle factors. Fisher's exact tests did not show any differences between the groups, and a Mann-Whitney U test did not show significant differences in education duration between the groups.

6.3.4 Change in egg intake – Correlations with participant characteristics

For all the demographic characteristics and lifestyle factors, change in egg intake during the intervention period was significantly correlated with higher sarcopenia screening score (r = .320, p = .025). For the baseline measures, change in egg intake during the intervention period was significantly correlated with higher BMI (r = .564, p < .001), and lower HR QoL (r = -.431, p = .002). Change in egg intake during the follow up period was significantly correlated with lower BMI at baseline (r = -.314, p = .030), and higher energy intake at baseline (r = .306, p = .034).

Table 6.4 Demographic characteristics and lifestyle factors in frequencies of participants and percentage of total group, for participants in the intervention group who increased egg intake and those who did not increase egg intake from T1 to T2 and T2 to T3.

	Intervention (T1 to T2)		Follow up (T2 to T3)	
	Increased egg intake (n=27)	No increase egg intake (n=22)	increased egg intake (n=19)	No increase egg intake (n=29)
Gender				
female	16 (59%)	12 (55%)	11 (58%)	16 (55%)
male	11 (41%)	10 (45%)	8 (42%)	13 (45%)
Education in years (Mean ± SD)	15 ± 4	15 ± 3	16 ± 4	15 ± 3
Marital status				
Married	17 (63%)	15 (68%)	13 (68%)	19 (66%)
Divorced/Widowed/Never married	10 (37%)	7 (32%)	6 (32%)	10 (34%)
Living status				
Alone	8 (30%)	6 (27%)	4 (21%)	9 (31%)
With others	19 (70%)	16 (73%)	15 (79%)	20 (69%)
Most recent employment level				
Unemployed/Manual/Non-manual	10 (37%)	9 (43%)	5 (28%)	13 (45%)
Professional/Management	17 (63%)	12 (57%)	13 (72%)	16 (55%)
Vegetarian/pescatarian/vegan				
No	26 (96%)	20 (91%)	18 (95%)	27 (93%)
Yes	1 (4%)	2 (9%)	1 (5%)	2 (7%)
Denture wearing				
No dentures	24 (89%)	19 (86%)	16 (84%)	26 (90%)
Partial/full dentures	3 (11%)	3 (14%)	3 (16%)	3 (10%)
Receiving help with food shopping				
Never	26 (96%)	21 (95%)	19 (100%)	28 (97%)
Sometimes/Often	1 (4%)	1 (5%)	0 (0%)	1 (3%)
Receiving help with food preparing				
Never	26 (96%)	21 (95%)	19 (100%)	28 (97%)
Sometimes/Often	1 (4%)	1 (5%)	0 (0%)	1 (3%)
Eating out or away from home				
Never/Sometimes	20 (74%)	18 (86%)	14 (74%)	23 (82%)
Often	7 (26%)	3 (14%)	5 (26%)	5 (18%)
Getting food delivered				
Never	23 (85%)	17 (81%)	17 (89%)	22 (79%)
Sometimes	4 (15%)	4 (19%)	2 (11%)	6 (21%)
Food Neophobia				
Food neophobic	18 (67%)	15 (68%)	13 (68%)	19 (66%)
Non food neophobic	9 (33%)	7 (32%)	6 (32%)	10 (34%)
Sarcopenia based on screening questions				
Sarcopenic	3 (11%)	0 (0%)	2 (11%)	1 (3%)
Non - sarcopenic	24 (89%)	22 (100%)	17 (89%)	28 (97%)
Sarcopenia based on handgrip strength				
Sarcopenic	3 (11%)	3 (14%)	2 (11%)	4 (14%)
Non - sarcopenic	24 (89%)	19 (86%)	17 (89%)	25 (86%)
Protein intake in g/kg of bodyweight /day				
Below 0.8 g/kg/day	5 (19%)	1 (5%)	1 (5%)	4 (14%)
Above 0.8 g/kg/day	22 (81%)	21(95%)	18 (95%)	25 (86%)
Protein intake in g/kg of bodyweight /day				
Below 1.2 g/kg/day	14 (52%)	12 (55%)	7 (37%)	18 (62%)
Above 1.2 g/kg/day	13 (48%)	10 (45%)	12 (63%)	11 (38%)
Previous participation				
Yes	1 (4%)	3 (14%)	3 (16%)	1 (3%)
No	26 (96%)	19 (86%)	16 (84%)	28 (97%)

* When frequency are given, for several variables the numbers do not add up to n=100 because some people left a question open.

6.3.5 Change in egg intake – group comparisons for reasons for eating/not eating eggs

Disagreement to statements concerning 'external reports' was significantly less strong for the participants who increased egg intake (2.53 ± 0.74) and those who did not increase egg intake during the intervention period (2.14 ± 0.69), U = 399.000, z = 2.073, p = .038. 'External reports' refers to how serious the participant would take external reports and recommendations about eggs and health from media and health professionals. Disagreement to statements concerning 'past' was significantly less strong for the group who increased egg intake during the follow up period (2.25 ± 0.62) than for those who did not increase egg intake (1.86 ± 0.75), U = 371.000, z = 2.041, p = .041. 'Past' refers to whether people had many eggs around, and remember many people eating them in the past, and/or being brought up with eggs.

Table 6.5 Mean and SD values for the components including reasons for eating or not eating eggs, for participants in the intervention group who increased egg intake and those who did not increase egg intake from T1 to T2 and T2 to T3. Scoring based on five-point Likert scale (strongly disagree to strongly agree).

	Intervention (T1 to T2)			Follow up (T2 to T3)		
	Increased egg intake (n=27)	No increase egg intake (n=22)	Mann-Whitney U Test	increased egg intake (n=19)	No increase egg intake (n=29)	Mann-Whitney U Test
Liking/Flavour/Variety	4.06 ± 0.51	4.01 ± 0.71		4.09 ± 0.52	4.01 ± 0.67	
Value for money	3.96 ± 0.42	3.99 ± 0.45		3.98 ± 0.38	3.97 ± 0.48	
Food chain	3.54 ± 0.60	3.86 ± 0.58		3.80 ± 0.54	3.60 ± 0.65	
Everyday food	3.62 ± 0.52	3.52 ± 0.70		3.68 ± 0.50	3.52 ± 0.68	
Effort	2.00 ± 0.37	2.06 ± 0.52		1.97 ± 0.36	2.04 ± 0.48	
Previous experience	1.49 ± 0.41	1.57 ± 0.53		1.64 ± 0.43	1.44 ± 0.47	
Past	1.95 ± 0.76	2.12 ± 0.68		**2.25 ± 0.62**	**1.86 ± 0.75**	p = .041
Occasion	2.24 ± 0.73	2.00 ± 0.65		2.26 ± 0.63	2.05 ± 0.75	
Stereotypes	1.83 ± 0.55	1.88 ± 0.57		1.82 ± 0.58	1.84 ± 0.53	
Sensory	3.37 ± 0.49	3.36 ± 0.73		3.40 ± 0.57	3.32 ± 0.63	
Expectations	1.83 ± 0.55	2.11 ± 0.85		2.00 ± 0.59	1.92 ± 0.80	
Willingness to change	2.85 ± 0.63	2.57 ± 0.89		2.74 ± 0.63	2.74 ± 0.85	
External reports	**2.53 ± 0.74**	**2.14 ± 0.69**	p = .038	2.42 ± 0.74	2.32 ± 0.76	
Eating less with aging	2.08 ± 0.54	1.97 ± 0.46		2.01 ± 0.45	2.03 ± 0.54	
Medical factors	2.56 ± 0.76	2.32 ± 0.70		2.61 ± 0.57	2.33 ± 0.83	
Moreish	1.74 ± 0.76	1.77 ± 0.53		1.84 ± 0.60	1.69 ± 0.71	
Suitability	3.33 ± 0.78	3.32 ± 0.89		3.26 ± 0.93	3.34 ± 0.77	
Familiarity	3.52 ± 1.01	3.77 ± 0.69		3.42 ± 0.84	3.76 ± 0.91	
Size	3.19 ± 1.08	3.14 ± 0.99		3.42 ± 1.02	3.03 ± 1.02	
Food safety	3.48 ± 1.01	3.82 ± 1.01		3.63 ± 0.96	3.62 ± 1.08	

6.3.6 Change in egg intake – Correlations with reasons for eating/not eating eggs

Change in egg intake during the intervention period was only significantly correlated with 'expectations' (r = -.296, p = .039). Change in egg intake during the follow up period was significantly correlated with 'previous experience' (r = .292, p =.044), and 'past' (r = .385, p = .007). None of the other reasons for eating or not eating eggs were significantly correlated with egg intake difference scores. 'Expectations' refers to how eggs are expected to be eaten in certain circumstances (e.g. whether they eat eggs with other foods or have a problem serving eggs at a dinner party). 'Previous experience' refers to whether people have had a bad experience in the past, or a family history of problems related to eating eggs, or a medical condition that restricts them from eating eggs.

6.3.7 Recipe feedback forms – Closed questions

After T2 test session 38 participants returned the recipe feedback form. Of those 22 (58%) participants said they used the recipes, while 16 (42%) said they did not use the recipes. Participants who used the recipes indicated when they had mostly eaten the recipes, where 55% ate the recipe dishes for lunch, 23% for an evening meal, 19% for breakfast, and 3% for another time of the day. Of the participants who used the recipes, 47% reported they used the recipes more than once or twice a fortnight.

After the T3 test session, 51 participants filled in the recipe feedback form. Of those 24 (47%) participants said they still used the recipes, and 27 (53%) said they had not used the recipes. Participants who used the recipes indicated when they had mostly eaten the recipes, where 63% ate the recipe dishes for lunch, 23% for an evening meal, 10% for breakfast, and 3% for another time of the day. Of the 24 participants who had used the recipes, 75% used them once/twice a month or less, while 25% used the recipes more than once or twice a fortnight. At T3 a question about the herb/spice packets was included, 85% of the participants who had used the recipes had also used the herb/spice packets.

The recipes most used were 'Buck rarebit', 'Salmon scrambled eggs', 'Cheese and ham eggy bread', 'Croque Madame', 'Spinach omelette with Salmon'. The recipes used least were 'Quinoa scrambled eggs', 'Turkish scrambled eggs', 'Turkish eggs with Turkish toast'.

6.3.8 Recipe feedback forms – Reasons for using or not using the recipes

Participants were asked several questions on why they decided to use or not use the recipes, why they choose specific recipes, and whether there is anything we can change about the recipes to encourage you and other people to prepare the dishes. Their responses to these questions can be summarized into several themes. Many of the reasons were similar to the reasons identified in the focus group discussion in chapter 3.

Reasons for choosing to use the recipes or not were often based on 'Liking', including liking or disliking certain eggs or any of the ingredients of the dishes, and on 'Combination' where foods/meals are liked or disliked because they are eaten in combination with other foods which may be liked or disliked.

"I don't like the taste or texture of eggs."

"Many of the recipes contain ingredients that I do not eat."

"I love smoked salmon with eggs."

"I don't like goat's cheese."

'Time and effort to prepare' were mentioned as reasons for using or not using the recipes. Many people mentioned thinking the dishes would take too much time to prepare as a reason not to use them, while others reported they recommended to change the recipes to be more quick and easy. People also mentioned thinking some recipes were too complicated, and that they preferred the recipes that were simple and had few ingredients. This may mean that the preferences for easy recipes may be related to 'Culinary skills' as well, the reasons are likely to overlap.

"I just haven't had time to give the recipes a try."

"Takes so much longer than boiling eggs."

"Make them quick and easy for lunch. We don't want to wait for oven to heat up for instance or spend time making sauces. We're busy people!"

"Too fiddly"

" I used easy ones but not those with multiple ingredients."

"More fiddly but worth it."

The participants' 'Culinary skills' were reported as reasons to not use the recipes. There were a few indications that especially the men did not cook often, and thought the recipes would be too difficult.

"I don't do much cooking, and they sounded a bit complicated."

"Don't enjoy cooking, [my] wife cooks. Seemed too much trouble."

Living situation or 'Other people present' was mentioned as a reason, where preferences of partners or children were a reason taken into account when choosing to use or not use the recipes. Alternatively participants reported that living alone influenced their eating habits and food choice.

"I would have tried more but my wife does not like spicy food."

"My husband was eating with friends and I needed a meal for one."

"Live by myself. Unsophisticated in cooking."

"Meals chosen with children's preferences in mind."

"Nice for veggie wife"

Increasing the dietary 'Variety' by using the recipes was mentioned either as a driver to use the recipes or as a barrier. Different people responded being willing to try new dishes, while others did not seem willing to change their dietary habits. Some mentioned they tried the recipes that were similar to meals they eat regularly. Alternatively 'Habit' and 'Familiarity' applied to those participants who did not seem

to like new ideas or variety, and did not want to change their usual diet, or preferred the recipes that were similar to meals they commonly have anyway.

“Try something new.”

“I am always looking for tasty alternatives for lunch.”

“[The recipes] Gave me ideas how to spice up eggs.”

“For a change of diet.”

“I tend to only experiment with new cooking ideas very occasionally.”

“I rarely choose to try out new recipes.”

“We are content with what we eat - plain + simple. Didn't really need these 'new ideas'.”

“Common dinner”

“It's one we have routinely anyway.”

“Prefer our own recipes - found them quite basic.”

From the focus groups it became clear that people differ in their willingness to eat more eggs or ideas about ‘Sufficiency’. Some people think the amount of eggs they eat is sufficient and do not wish to eat more.

“I didn't feel I needed them. I feel there are enough eggs in my diet.”

“I eat an average of at least one egg per day without bothering to use any new recipe. I did not feel any need.”

“..mainly because I don't want to eat more than the 6 eggs/week I already eat.”

“I already eat eggs 3/4 times a week. I do not want to change.”

“I am scared of allergies and changing my eating pattern. I stay with what I know I'm safe with."

Participants mentioned preferences for different portion sizes. This is related to what in the focus groups was labelled as ‘Substantial meal’, with participants referring to a food as a snack food or a meal. In the feedback, some people reported thinking the portions of the meals were too big and should be lighter, while others recommended to add suggestions of accompaniments to make the meals bigger.

“Make them into meals rather than lunch/breakfast light dishes.

“The recipes seemed to be presented as breakfast/brunch. Perhaps some suggestions of accompaniments to change them into a main evening meal? I cannot break the habit of small breakfasts.”

“Suggestions of what to serve with the eggs to make a main meal other than breakfast.”

“Make them lighter. The 2 or 3 we tried were very rich.”

Some participants mentioned reasons related to weight management or ‘Restraint’, these reasons referred to not wanting to change anything in their diet, not picking certain recipes, or thinking the portion sizes were too big.

“I am worried we would gain weight if eating these portions + not eat the rest of the day.”

“I follow an eating plan of my own devising in order to regulate my weight.”

“Some of the ingredients are not able to be used in a calorie controlled diet.”

‘Spoilage/wastage’ was mentioned as a reason to eat or not eat eggs, and therefore use or not use the recipes.

“I would make cakes with them but that's all. I don't normally buy eggs. I used one recipe to use up eggs after baking.”

“I do not eat eggs! I don't want them to go off after buying. I buy them in restaurants, but don't eat them at home.”

“Good for using up left over ham”

“Had naan bread to use”

Another reason many people mentioned was the ‘Availability’ of the ingredients or appliances needed for the recipes. Specific recipes were chosen because the ingredients were at hand, or recipes were not used because e.g. they required a microwave and the participants did not own a microwave.

“Some of the recipes included ingredients in our cupboard.”

“Used the ones which used ingredients we had to hand.”

“Don't have a microwave.”

Lastly, participants were asked why they chose to use/not use the herb/spice packets. Examples of the comments specific to the herb/spice packets are given below.

“*Good to have the herbs + spices in sachets.*”

“*Lovely touch you put in small packets of spices + herbs.*”

“We already had all the herbs + spices.”

“Acid reflux - can't eat spices”.

6.4 Discussion

This chapter was aimed to explore how the participants who increased their egg intake during the intervention period differ from the participants who decreased or did not change their egg intake during the intervention period, in relation to the demographic characteristics, lifestyle factors, and baseline measures. Additionally the recipe feedback forms were reviewed to find barriers and facilitators to using the recipes, and explore how the study design could improve for future research. The following sections report on how the participant characteristics are related to change in egg intake, how the reasons for eating or not eating eggs were related to change in egg intake, and the barriers and facilitators to using the recipes from the recipe feedback forms.

During the study participants in the intervention group were offered a variety of different types of recipes. It was assumed they would find some recipes more appealing than others, and hopefully find some recipes they would like to try out. However, the variance in egg intake was very high. The results show that the difference scores in the intervention group range from -32 to +56, and only 40-55% of participants increased their egg intake. This suggests that not all participants used the recipes and that the intervention strategy did not work for all participants. Figure 6.1 shows that the participants who increase egg intake during the intervention period are not all the same participants as those who increase egg intake during the follow up period. The recipes used most often tended to include ingredients and combinations of foods that may be more familiar to UK older adults (e.g. baked beans, salmon, ham), while the recipes that were used least often included ingredients and combinations of foods that may not be familiar to UK older adults (e.g. quinoa, poached eggs in yoghurt),

Exploring how the participant characteristics were related to change in egg intake during the study showed that the current intervention strategy increased egg intake for specific subgroups. The participants who increased egg intake during the intervention period had a higher BMI, a lower health related quality of life, and were more likely to be sarcopenic (based on the screening questions (Malmstrom & Morley, 2013)). The participants who increased egg intake during the follow up period tended to have a lower BMI and higher energy intake at baseline. Exploring the reasons for eating or not eating eggs in relation to change in egg intake showed the detail to which individual differences between people can make a difference in

their response to intervention strategies. The participants who increased egg intake during the intervention period took external reports from media or health professionals more seriously, and felt less strong about expectations on how to eat eggs (e.g. not eating eggs with other foods, or not serving it at a dinner party). The results also showed that participants who increased their egg consumption during the follow up period agreed less strong with statements about being brought up with eggs around, and are more likely to have had bad previous experiences with eggs. The participants' feedback was related to several reasons for using or not using the recipes, including: liking, time and effort to prepare, culinary skills, other people present, variety, habit and familiarity, sufficiency, substantial meal, restraint, spoilage/wastage, and availability.

6.4.1 Participant characteristics

The results showed that BMI was related to change in egg intake. Previous chapters already showed that higher egg intake was predicted by higher BMI (section 4.3.3 in chapter 4, and section 5.3.3 in chapter 5). This may be explained by the unhealthy lifestyles that have been associated with high egg intake (Djoussé et al., 2009; Hu, Stampfer, Rimm, et al., 1999; Ruxton et al., 2010). The current results show that people with a higher BMI also had a greater increase in egg intake when they were exposed to the recipes. This was shown in the participants who increased their egg intake compared to those who did not increase, and in the correlations with greater change in egg intake related to higher BMI at baseline. Contrary to the intervention period, baseline BMI is lower in the group of participants who increase egg intake during the follow up period, and BMI negatively related to egg difference scores. Higher energy intake at baseline also positively correlated with egg difference scores during the follow up period. Higher egg intake has been related to high energy intake in other studies (Djoussé et al., 2009). Participants may have taken longer to respond to the recipes, kept the recipes, and reused them after the intervention period.

Participants with a higher BMI were more likely to increase egg intake when they received the recipes every two weeks than when they were not coming anymore. It is unclear why these participants showed a higher egg intake than other older adults. The positive association between BMI and egg intake may be explained by appetite. The study did not include questions about feelings of appetite. This should be taken into account when interpreting the results. However, total energy intake

was not different for those who increased their egg intake or did not increase their egg intake. The arrival of recipes may have been a type of food cue. Overweight or obese individuals are more likely to be influenced by attentional bias to food related cues (Hendrikse et al., 2015; Nijs & Franken, 2012), and increase intake after exposure to pictures of food (Nijs, Muris, Euser, & Franken, 2010). The results also show that those participants with higher BMIs were less likely to continue to increase their egg intake in the follow up period. Maybe they were less likely to reuse the recipes because they were not reminded or affected by the food cues, or because they finished the herb/spice packets. Sensitivity to food cues was not measured as part of this study, so it is unclear whether this has affected the results. Avoiding spoilage and wastage is an important determinant for this target age group (Appleton, 2016; Best & Appleton, 2013; Falk et al., 1996), which may have affected the use of recipes. It is however unclear how this relates to BMI or energy intake. If the recipes are not re-used after a while maybe keeping the recipes is a barrier, it may help to make them more hardwearing, or provide a way to collect and store them in (e.g. folders/binders). The follow up period included Christmas and New years for eight out of ten cohorts, this may affect dietary intake during this period of time (Reid & Hackett, 1999). Moreover, New Year's resolutions, especially for those with higher BMI may be related to dieting behaviour (Serdula et al., 1999), which may make it less likely people will try new recipes.

Greater change in egg intake during the intervention period was significantly related to higher sarcopenia screening scores, and lower health related quality of life. These results suggest greater increase of egg intake during the intervention period was related to poorer health at baseline. Older adults with poorer health may have more difficulties with preparing meals, and eating capabilities e.g. biting, chewing, or swallowing, which can affect nutritional status and food choice (Appleton, 2016; Best & Appleton, 2013; Maitre et al., 2014; Nieuwenhuizen et al., 2010; Sheiham, Steele, Marcenes, Tsakos, et al., 2001; Smith & Gray, 2016; Walls & Steele, 2004). It has been shown that grip strength is linked to oro-facial muscle strength, and correlates with tongue pressure and biting force (Laguna et al., 2015). Since low grip strength is an indication of muscle loss (Lauretani et al., 2003), this suggests that eating difficulties may be a common problem among sarcopenic older adults. Protein intake, and egg intake, have been related to the treatment of sarcopenia (Cruz-Jentoft et al., 2010; Smith & Gray, 2016). The literature review in chapter 2 described how eggs may be of help to increase protein intake in older adults. Eggs are a nutrient dense high quality protein rich food, and compared to other protein rich foods, they are of soft texture and easy to cook (Lewis & Bashin, 1988). If the

intervention worked especially for those at risk of sarcopenia, even in a relatively healthy sample, this could have a great impact on adverse health effects.

6.4.2 Reasons for eating or not eating eggs

Comparing the groups of participants who increased egg intake during the study, to those who did not increase for reasons for eating or not eating eggs, significant differences were found. The questionnaire statements with the components can be found in table 4.2, chapter 4. There was a significant difference in the component 'external reports'. The people who increased egg intake during the intervention period, disagreed less strongly with taking recommendations from newspapers and radio very seriously, and agreed less strongly with eating eggs regardless of media reports about salmonella, and eating eggs regardless of what health professionals recommend. The influence of external reports on eating behaviour whether it is recommendations from the media or from health professionals seem to be taken more seriously by the participants who increased their egg intake during the intervention period than those who did not increase egg intake. Other studies have reported how older adults are confused after changes in nutritional guidelines and tend to be skeptical to the reliability of external advice about nutrition (Best & Appleton, 2013; McKie et al., 2000; van der Zanden et al., 2014a). After the salmonella scare in 1988, the UK egg consumption dropped overnight (BBC-news, 1988; British-Egg-Industry-Council, 2016b). The egg's reputation for potential health threats was long lasting, it took until 2014 to get egg consumption back to the level it was before the Salmonella scare (Poulter, 2015). A recent update on the microbiological risk from eggs by the Advisory Committee on the Microbiological Safety of Food (ACMSF) recommends that "Lion code eggs (or eggs produced under equivalent schemes) can be served raw or lightly cooked to those in vulnerable groups, including pregnant women, the young and the elderly" (Coia et al., 2016). People who are more likely (or less unlikely) to follow external reports and advice about eggs, may have been more affected at the time, but they may also be more likely to be reassured by the recent external reports on the safety of eating eggs. The credibility of Bournemouth University as a source of the recipes may also have encouraged them to use the recipes and increase egg intake. Moreover, all participants received the 'dietary information postcard' and each recipe mentioned that it was high in protein. This information may have had a stronger effect on these older adults who were less skeptical, which may have motivated them to use the recipes. This suggests that more people may try out recipes in supermarkets,

magazines or on television shows, if the health benefits and nutritional values of the meals were mentioned. Participants who did not increase egg intake seem to take external reports less seriously. This skepticism has previously been related to confidence in knowing the requirements of their own body, conflicting and frequently changing nutritional advice, adverse health effects of others who followed nutritional advice, and lack of trust in scientific background of the advice (McKie et al., 2000). It may be very challenging to overcome this skepticism if the older adults do not trust nutritional information or health professionals. Individual dietary advice focused on their personal preferences, habits and health beliefs may work.

When looking at the correlations with reasons for eating or not eating eggs, significant correlations showed that egg intake changes during the intervention period were negatively related to 'expectations'. The component labeled 'expectations' includes statements about never eating eggs with other foods, not serving eggs at a dinner party, and eggs not being appealing. If older adults find eggs not appealing, they are probably not increasing their egg intake. In this case possibilities are very limited and focus on protein rich foods other than eggs may be more effective in increasing protein intake. Since all the recipes included combinations of eggs with other foods, agreement to never eating eggs with other foods would naturally be negatively correlated with using the recipes. Interestingly, this component also includes the statement about status (serving eggs at a dinner party). It was hoped that the recipes would affect the idea that eggs can only be served in a plain and simple way. However, it seems like the people with stronger ideas about this were less likely to try the recipes. A stronger focus on the more "fancy" recipes, e.g. the recipes designed by well-known chefs, may help in overcoming this specific barrier. A better design with coding/categorization of the recipe cards to make it easier to find which recipes are designed by chefs may also help for people who may like to use those specific recipes, and/or if recipes would be categorized according to the different characteristics.

For the component 'past', there were significant differences between the groups of participants who increased egg intake during the follow up period and those who did not, and a significant correlation between the degree of change in egg intake and agreement with the statements. Increasing egg intake during the follow up period was related to disagreeing less strongly with that there were not many eggs around when they were younger, and that they were not brought up eating eggs, and agreed less strongly with the statement that many people used to eat eggs when

they were younger. The mean values in table 6.3 suggest that for both groups the participants seem to have been brought up eating eggs, had many eggs around when they were younger, and many people were eating eggs when they were younger. However, the participants who increased their egg intake during the follow up period agree less strongly with these types of statements. Other studies show that past behavior and upbringing have a strong influence on eating behavior in older adults (Best & Appleton, 2013; Edfors & Westergren, 2012; Falk et al., 1996), and eating eggs especially seems to be highly habitual (Conrad et al., 2017). If older adults are already used to eating their eggs the way they have always eaten them, they may be less willing to try the new recipes. The participants who increased their egg intake during the study tended to have a lower egg intake at baseline, suggesting that their past behavior may have not encouraged them to eat eggs as much as the group of participants who did not increase egg intake during the study. Most recipes in the intervention were not traditionally English. This may have been a barrier to using them for those participants whose egg intake is strongly influenced by their upbringing. High protein recipes that are more similar to traditional meals may be more effective than the recipes that were currently used for the older adults who are affected stronger by 'past'.

Egg intake change during the follow up period was positively correlated with the reasons labeled as 'previous experience'. Stronger disagreement with the component 'previous experience' included stronger disagreement with having a family history of problems after eating eggs, having had bad experiences with eggs in the past, and not eating eggs because of a medical condition. Table 6.5 shows that mean scores were low for either group, but this correlation suggests that the participants who have increased egg intake during the follow up period disagreed less strongly with having had bad experiences, a family history of problems with eggs, or a medical condition. This indicates they agreed slightly more to having medical conditions, family histories or bad experiences as a barrier to eating eggs. These dietary restrictions may be related to lower habitual intake at baseline, which may be related to greater increase in egg intake (Vickers & Altman, 2001). Exposure to the recipes may have been a 'situational cue' reminding these participants to try eggs again (van't Riet et al., 2011). These barriers might be very difficult to overcome and for those affected by them focusing on other protein rich foods could possibly be more effective than promoting egg intake.

6.4.3 Recipe feedback forms

Of all the intervention group participants, about half of them said they used the recipes, and of those, most people used them less than twice a fortnight. This suggests that while this strategy worked for a subgroup of participants, other intervention strategies may appeal more to the other participants.

Most participants who used the recipes had used them for lunch. The intervention study was focused on breakfast, but lunch is also generally too low in protein content to reach the optimal protein threshold of 25g per meal/eating occasion (Berner et al., 2013; Tieland, Borgonjen-Van den Berg, et al., 2012; Valenzuela et al., 2013). This indicates that for the people who used the recipes, this strategy increased the use of protein rich recipes for a meal that is generally low in protein. Unfortunately baseline distribution of protein intake was not measured for the participants in this study. However, in case it can be assumed that the participants' lunch protein content was similar to large observational survey studies (Berner et al., 2013; Tieland, Borgonjen-Van den Berg, et al., 2012; Valenzuela et al., 2013), the intervention would have increased protein intake for this meal, and added an eating occasion of reaching the optimal protein threshold, which would increase rates of muscle protein synthesis (Loenneke et al., 2016; Murphy et al., 2016).

Most participants (85%) who used the recipes reported they also used the herb/spice packets. Although several studies show enhancing flavour of foods can increase intake within a meal (Appleton, 2017a; Appleton, 2009; Best & Appleton, 2011; Mathey et al., 2001; Schiffman, 1998; Schiffman & Warwick, 1993), other studies do not find an increased intake, or not for all foods included in the meal (Essed, Kleikers, van Staveren, Kok, & de Graaf, 2009; Essed, Oerlemans, et al., 2009; Koskinen, Kälviäinen, & Tuorila, 2003a). These conflicting results indicate flavour enhancement may not work for all foods; moreover, there may be individual differences in flavour preferences and degree of sensory impairment. This may also explain why the recipes and herb/spice packets did not appeal to some participants.

Themes mentioned related to using or not using the recipes were similar to some of the reasons for eating eggs identified in the qualitative study (chapter 3). Some of these (e.g. liking, variety) were also significantly related to egg intake in the questionnaire study (chapter 4). Previous work has shown that the reasons 'liking', 'time and effort', 'other people present', 'habit', 'familiarity', 'restraint', 'spoilage/wastage' and 'availability' are also related to intake of other protein rich

foods in older adults (Appleton, 2016; Best & Appleton, 2013; Herrema et al., 2017). For recipes this shows that including staple / everyday type of foods as ingredients could potentially facilitate use of the recipes, because the foods are probably liked (also by other people in the house), familiar, available, and they can use them to avoid spoilage and wastage.

Many protein-rich foods require cooking and some participants indicated that they do not normally cook and therefore did not use the recipes. These comments were grouped as 'culinary skills'. Studies show that culinary skills or physical ability to cook can be a barrier to cooking meals (Adams et al., 2015; Allaire et al., 1991; Caraher et al., 1999; Hughes et al., 2004). For the current study the comments varied between not using the recipes because they are thought to be "*too fiddly*" or difficult, and not using the recipes because they were thought to be "*quite basic*" compared to the recipes regularly used at home. For future research it would be important the recipes are categorized clearer based on cooking difficulty, to increase the likelihood that the recipes appealing to different people can be found easily.

Adding variety has been related to increased food intake in older adults (Hollis & Henry, 2007) and specifically egg intake (chapter 4), the comments showed 'variety' was not preferred by everyone. Recipes could be adjusted to individual preferences, e.g. a protein rich variation of a familiar traditional meal, versus more unusual new foreign dishes. Future research could identify which types of meals would appeal more to which types of people. This could then be used to provide different types of meals so recipes may appeal to more people.

'Substantial meal' was used to label the comments about the meals being too small for a main evening meal, or comments about preferring lighter meals. This may be related to 'dietary restraint', because the feedback also included comments on the portions being too big and worries about gaining weight. It has been shown that many older adults, especially women, actively restrict their food intake to lose weight (Donkin et al., 1998; Hetherington & Burnett, 1994). The recipes contained a variety of portion sizes and energy content. For future studies the recipe cards could be designed to facilitate selecting a recipe based on the preferred energy content.

'Sufficiency' refers to the comments from participants who think the amount of eggs they eat is sufficient and do not wish to eat more. This has come up in the focus

groups (chapter 3) and in the questionnaire study (chapter 4), and seems to be specifically related to relatively high intake of eggs. Although, for a survey about fruit and vegetable intake in older adults one of the most common responses was that they would not want to eat more fruit and vegetables because they believe they already eat enough fruit and vegetables, while intake was often not high enough (Appleton et al., 2010). This may be particularly challenging to change. Studies have shown that factors like dietary advice from health professionals, and nutritional information may help to convince people to change their eating behaviour, even if they feel they do not need it (Herrema et al., 2017; van der Zanden et al., 2014a).

6.4.4 Strengths and limitations

As part of the feedback forms, participants responded with yes or no to the question about using the recipes. For the main analyses the difference scores in egg intake rather than these responses were used as a measure of using the recipes for several reasons. As mentioned above, at T2 not all the participants in the intervention group filled in the recipe feedback form, while the egg intake responses were complete, so there were more missing values in the responses to the feedback forms. Moreover, the egg intake measure is also thought to be less sensitive to demand characteristics (Faith et al., 1998). After receiving the recipes for three months, the participants may feel like they should say they have used them. Filling in egg intake is not a direct measure of using the recipes provided as part of the intervention and may therefore be less sensitive this type of bias, but this should be taken into account when interpreting the results.

Although increases in egg consumption are used as a measure of using the recipes, it is assumed that the decreases in egg intake are not a response to the recipes/ intervention. This chapter was focused on exploring the reasons for increasing egg intake in the intervention group, and therefore did not look for what may be related to the increase in egg intake in the control group participants. However, it should be taken into account that part of the increase in egg intake in the intervention group may be due to factors that also applied to the control group, i.e. factors other than the recipes.

The sample sizes for these exploratory analyses are low, and many statistical tests are conducted. These factors should be taken into account when interpreting the results. However, by conducting correlations as well as comparing groups (of

participants who increase egg intake with those who did not increase egg intake), the analyses allow exploring whether those participants who increase egg intake are different from those who did not increase, and also the relation between the continuous range of egg intake decreases/increases and the variables of interest.

Recipe use is not referred to as ‘compliance’ because there were no specific instructions to use the recipes. If instructions were provided, maybe more participants or different types of participants would have used the recipes.

6.5 Conclusions

These results suggest there are individual differences between the participants who increase and those who did not increase egg consumption, and between those who increase a little and those who increase a lot. However, they also show that there are individual differences between the participants increasing egg intake during the intervention period (receiving the recipes), and participants increasing egg intake after the intervention during the follow up period.

Differences between participants were related to BMI, energy intake, health related quality of life and sarcopenia. Additionally increase in egg intake was related to some of the reasons for eating or not eating eggs, including: how serious recommendations from media and health professionals are taken (external reports), how strong people feel about how eggs should be eaten (expectations), agreement to having many eggs around when they were younger (past), and agreement to having had bad experiences with eggs in the past (previous experience). These individual differences can be addressed in future research studies.

Lastly, the recipe feedback forms showed that about half of the participants in the intervention group said they used the recipes. Most participants who used the recipes had used them for lunch, and also used the herb/spice packets. This suggests that while this strategy was beneficial for a subgroup of participants, other intervention strategies may appeal more to the other participants.

6.5.1 Implications for future research

Many of the reasons mentioned for using or not using the recipes could be related to including ‘staple’ foods in the recipes, e.g. bread, milk, ham or cheese. Foods that are liked, familiar, will be available in the kitchen cupboards/fridge, and can be used to avoid spoilage and wastage. Additionally the design of the recipe cards could be optimized to make it easier to identify preferred types of recipes in a variety of recipes available. Older adults have personal preferences and habits, including different culinary skills, variety seeking preferences and taste preferences. If recipes are designed to make it easier to find the ones that are appealing for older adults with specific individual preferences, more older adults may be willing to use them.

For future research keeping and reusing the recipes could be facilitated by providing a way to store them. Because some participants seemed to only increase egg intake during the intervention period, and not re-use them during the follow up period, a folder or binder with dividers could make it easier to keep the recipes and find those in a category that you are interested in. The results also showed that it may be important to add nutritional information and related health benefits to the recipes, for those older adults who respond to external reports.

Lastly, it may be possible that the use of recipe cards, or the focus on increasing egg intake just does not work for some older adults, and that they would respond better to another intervention strategy. Future research should focus on how to identify the subgroup for which the recipes could be beneficial.

The next chapter, chapter 7, will be a general discussion of this PhD project, including the key research findings in relation to the aim and objectives, the challenges faced in the current research, the next steps for future research, and a final summary.

7. General discussion: research findings, challenges, and future research implications

This chapter will discuss the key research findings of this PhD project in section 7.1, focussing on each of the three objectives and on the overall aim. Section 7.2 will review challenges that emerged in the current research and next steps for future research. Section 7.3 will give a final summary.

7.1 Key research findings

7.1.1 Objective 1: Identify the reasons for eating or not eating eggs in older adults.

Chapter 3 describes how focus groups and interviews were used to identify the reasons for consuming or not consuming eggs in older adults. A total of 42 individuals took part in one of eight focus groups or two individual interviews. Focus groups were designed to be mixed, or include exclusively males, females, people who work, and people who do not work. The participants were 22 females and 20 males, aged 56 to 96 years old. Using thematic analyses, 69 different reasons were identified as reasons for eating or not eating eggs. The reasons were grouped into 13 themes using semantic reasoning:

- Hedonics: appeal, liking
- Properties of the food: appearance, complete, flavour, freshness, moreish, odour, quality, satiating effect, size, texture
- Preparation style: combination, processing
- Convenience: convenience, culinary skills, effort to prepare, planning, practicalities, time to prepare
- Physical environment: experience, availability, cost, financial situation, standby, value for money
- Variety: replacing foods, variety, versatility, wide variety of choice
- Food safety: food safety, food scares, spoilage and wastage
- Physical health/abilities: appetite, digestibility, eating abilities, genes, medical factors, physical abilities, sensory abilities

- Nutrition and health knowledge: balanced diet, health beliefs, nutritional knowledge, recommendations, restraint, sufficiency, value
- Social environment: culture, other people present, politeness
- Morality: animal welfare, environmental issues, food origins, moral values
- Emotion: comfort, masculinity, status, treat
- Habit: familiarity, habit, previous experience, substantial meals, staple food, suitability, trying new things, trend, upbringing

The themes are used for presentation of the results. The questionnaire study focussed on the 69 individual reasons, not the themes. This study has shown that British older adults have many reasons for eating or not eating eggs.

7.1.2 Objective 2: Find the reasons for eating or not eating eggs which are associated with habitual high egg consumption in older adults.

Chapter 4 describes how the reasons for eating or not eating eggs, identified in a focus group study, were then used in a structured questionnaire. The questionnaire assessed: frequency of habitual egg intake, frequency of habitual intake of other protein-rich foods, agreement or disagreement with 76 statements on the reasons for eating or not eating eggs, and various demographic characteristics and lifestyle factors. The questionnaire was sent out to a National sample of 1082 adults. Responses from 230 participants (110 females and 120 males, aged 55 - 80+ years, from across the UK) were included in analyses. A Principal Component Analysis on the 76 statements generated 20 components, which were then analysed for their relative importance in predicting habitual egg consumption using a multiple linear regression model.

The results reveal that the questionnaire can significantly predict habitual egg consumption in a population wide sample of British older adults. The reasons significantly related to egg consumption reveal several topics to focus on when designing strategies to increase egg consumption in older adults: improving liking, tastiness and adding variety; less focus on eggs as value for money; eating eggs as an everyday type of food; reducing stereotypes about who does and who does not consume eggs; willingness to increase egg intake; making it easier to eat more eggs after initial tasting; and by promoting eggs for people who have noticed the

effects of ageing on their food intake. The results also showed that higher protein intake of non-egg protein rich foods and a higher Body Mass Index (BMI) were related to greater egg intake.

7.1.3 Objective 3: Find whether an intervention study, designed to specifically focus on the reasons found most strongly predicting egg intake, can increase egg consumption in older adults.

At the start of this PhD the objective was to use a bottom up approach. The main focus of the intervention study would be based on the outcomes of the questionnaire study (objective 2), which were based on the outcomes of the qualitative study (objective 1). The questionnaire study showed several outcomes that were significantly related to habitual egg consumption. Based on these results, the component including the reasons 'flavour' and 'variety' was chosen to focus on for the design of an intervention study.

Chapter 5 reports on the details of a randomized controlled intervention study which was designed to increase egg and protein intake, by providing recipes of protein-rich egg-based meals and herb/spice packets to encourage the addition of flavour and variety to the diet. Community dwelling adults aged 55 years and over were randomized to receive dietary information followed by either 6 recipes and relevant herbs/spices every fortnight for 3 months, or northing further. Dietary intake (Food Frequency Questionnaire), body composition (Bioelectrical Impedance Analysis), handgrip strength, leg extensions and physical performance (Short Physical Performance Battery) were assessed at baseline (T1), and again after the 3-month intervention period (T2) and at a 6-month follow up (T3). A total of 100 participants took part, 54 females and 46 males, aged 55 to 97 years old.

The results showed that being in the intervention group was significantly related to higher egg intake at T3, after the follow up period. However, directly after the intervention, at T2, being in the intervention or control group did not predict egg intake. Mean values show that both groups increased egg intake from T1 to T2 during the time of the intervention. Although for the intervention group, egg intake remains high from T2 to T3, while the control group's egg intake decreases to be similar to baseline egg intake values again.

The results also show that egg intake is strongly predicted by baseline egg intake, which shows egg intake tends to be habitual (which was also shown in the outcomes of the other two studies). Egg intake was also predicted by total protein intake; this was shown in the questionnaire study in this thesis as well (chapter 4). Higher egg intake at T2 was predicted by higher BMI, and higher egg intake at T3 was significantly predicted by higher age.

7.1.4 Aim: To explore the barriers and facilitators specific to egg intake in older adults, and use these in a food-based approach to increase egg and dietary protein intake in community dwelling British older adults aged over 55 years old.

For this PhD project, an inductive approach was used to design an intervention study. The sections above (section 7.1.1-7.1.3) describe how the intervention was based on one of the outcomes of a questionnaire study, which was based on a qualitative study. An extensive list of reasons for eating or not eating eggs in older adults was identified using qualitative research. These reasons were then used to relate to egg consumption in a large National sample to find whether the reasons tend to be a barrier or a facilitator to egg consumption in older adults. One of the most important determinants of egg intake was then used as a topic to focus on during the design of an intervention study to increase egg intake in older adults. Using a 'bottom up' approach was successful in finding a strategy that can increase egg consumption in older adults.

The current research used a food-based approach, by focusing on egg intake in older adults. This intervention aimed to increase egg and protein intake by providing high-protein egg-based recipes and herb/spice packets, specifically designed to add variety and flavour to protein rich meals. All recipes included eggs and other protein rich (conventional) foods, so that the total protein content per recipe meal was at least 25g of protein. Total protein intake was not significantly different between the intervention group and the control group, after the intervention or after the follow up period. However, exposing older adults to the recipes had increased mean intake of eggs for the intervention group at the follow up test session. Egg intake at T3 was significantly higher in the intervention group than in the control group. Providing recipes and herb/spice packets seems to be successful as a strategy to increase

egg intake, but not total protein intake, in older adults. However, the variance was large, and the wide range in egg intake and changes in egg intake show that there were large individual differences in how people responded to the intervention.

Lastly, the current research included older adults over 55 years old, with an aim to include adults who would benefit from prevention as well as treatment. The research studies as part of this PhD were all targeted at adults aged 55 years and older. The intervention was aimed at individuals over 55 years old, after it was based on the questionnaire and the qualitative study including adults over 55 years old. Within this age range, egg intake does not differ with age under normal conditions (this can be seen in the cross sectional questionnaire study in chapter 4, and baseline intake of eggs for the intervention study in chapter 5). After the intervention age did not predict egg intake at T2, but after the follow up (at T3) higher age was related to higher egg intake. This suggests that the change in egg intake from T1 to T3 may be greater with higher age within this age range, and this strategy may not have increased egg intake as much in the younger participants of the age range, as for the older participants.

7.2 Challenges in the current research and next steps for future research

Specific strengths and limitations for each study have been discussed in the corresponding chapters. This section will discuss the general challenges in the PhD research project, and how what was learned during the projects can be taken further into future research.

7.2.1 Using general strategies vs personalised dietary guidance

The challenges faced during this PhD project include individual differences. The qualitative study described in chapter 3 showed there are many reasons for eating or not eating eggs. The questionnaire study in chapter 4 showed that agreement with the reasons can be different in different subgroups (of high and low egg consumers). The intervention study described in chapter 5 and 6 showed a large variance between participants and individual differences related to their change in egg intake during the intervention.

It was considered a strength of the intervention study in chapter 5 that the strategy was general (not personalised), with the same selection of recipes for each participant in the intervention group. However, there are some indications that if the participants would have been approached in a way that may appeal more to their personal preferences and habits, more participants may have used the recipes and increased their egg and protein intake.

'Habits and routines' are among the most important drivers to follow dietary recommendations (van't Riet et al., 2011), which can make it challenging to change eating behaviour. However, habits and preferences differ between individuals. Older adults with different preferences for taste or variety (e.g. familiar traditional meals vs new ideas) may respond differently to different recipes.

The elderly population is strongly heterogeneous, varying greatly in physiology as well as psychology (den Uijl et al., 2014). Older adults may suffer from several different levels of physical abilities, eating capabilities, and sensory functioning, which would affect their food choice and their ability to prepare food (Allaire et al., 1991; Best & Appleton, 2013). Moreover, they have a long history of meal experiences, preferences, food related emotions and habits that may influence their current eating behaviour (Axelson & Penfield, 1983; den Uijl et al., 2016). Different older adults with different ages, health statuses, or eating behaviour may have different barriers and facilitators to eating behaviour, and consequently may benefit from different interventions.

Several studies have shown that personal advice from a dietician and customized recommendations based on habits and personal preferences helped to increase protein intake in community dwelling older adults and hospital patients (Beermann et al., 2016; Herrema et al., 2017). In another study with elderly participants in focus groups regarding the use of protein enriched foods, the older adults indicated that they would follow advice from their family doctor without questioning it (van der Zanden et al., 2014a). This suggests that health professionals can play an important role when it comes to changing eating behaviour in the elderly. Individualised dietary counselling by dieticians improves energy and protein intake (Baldwin & Weekes, 2011; Munk et al., 2016), and dietary advice with or without ONS has been related to benefits to body weight and energy intake (Baldwin & Weekes, 2012; Baldwin & Weekes, 2011).

The general approach in the intervention study was thought to be a strength, however, the effect of the intervention may have been greater with more personalised dietary guidance. Individual dietary advice by health professionals may not be feasible, as this would be expensive and requires more time, motivation and engagement from the target group. However, it may be possible to customize interventions, in this case recipes, to groups of older adults. Not much is known about the segmentation of this age group (den Uijl et al., 2014; van der Zanden et al., 2014b). Future research could potentially focus on identifying segments of older adults with different barriers and facilitators (e.g. culinary skills). For example, if recipes could be designed specifically for people with basic culinary skills and marketed/ advertised specifically to appeal to this group, there may be more individuals willing to try to use them.

For this project the intervention was based on the specific barriers and facilitators for this target population. The 'Behaviour change wheel' developed by Michie and colleagues demonstrates that behaviour change interventions that either address challenges or maximise facilitators will have increased chances of success compared to those less developed (Craig et al., 2008; Michie et al., 2011). Alternative models/techniques focussed on health behaviour change may be considered for future studies, e.g. habit formation (Lally & Gardner, 2013) or implementation intentions (Gollwitzer & Sheeran, 2006) can be taken into account when designing an intervention. Models like the Theory of Planned Behaviour are often used to identify determinants of health behaviour (Godin & Kok, 1996), however for this project we have chosen a more inductive 'bottom up' approach to find specific barriers and facilitators using qualitative research. Moreover the Theory of Planned Behaviour is based on the assumptions that eating behaviour is planned, or affected by cognitions, and that having an intention to change behaviour will results in behaviour change. While previous work has shown that eating behaviour is strongly affected by habits and hedonism, and that the majority of intentions do not result in actually adopting new behaviours (Sheeran, 2002; Steptoe et al., 1995).

7.2.2 The acceptability and appropriateness of different protein rich foods for breakfast

Another strength of this project was the food based approach to increasing dietary protein intake. Section 2.2.6 of the literature review showed that conventional foods

may be more easily accepted when trying to encourage older adults to increase protein intake (Gosney, 2003; Kennedy et al., 2010; van der Zanden et al., 2014a, 2015). During the focus groups (chapter 3) people talked about when they think it's suitable to eat eggs or a certain type of eggs, this reason was labelled 'suitability', while Chapter 4 shows that specific types of egg preparations were eaten more at specific times of day. The intervention in chapter 5 was focussed on breakfast because this tends to be the meal lowest in protein (Berner et al., 2013; Tieland, Borgonjen-Van den Berg, et al., 2012; Valenzuela et al., 2013), and in the UK eggs are generally accepted as a breakfast food (Smith & Gray, 2016). However, in the recipe feedback forms the participants indicated that the recipes were mostly eaten at lunch. Not accepting the high protein meals for breakfast was another challenge that emerged from the results of this PhD research.

Besides breakfast, the non-main meal (often lunch) also tends to be too low in protein to reach the optimal protein threshold (Berner et al., 2013; Tieland, Borgonjen-Van den Berg, et al., 2012; Valenzuela et al., 2013). Therefore using the recipes for lunch may add another eating occasion with more than 25g of protein and consequently health benefits (Loenneke et al., 2016), however it also shows there may be specific barriers to eating more protein at breakfast. The feedback form did not specifically ask why the meals were eaten at certain times. Time and effort to prepare the dishes were mentioned as one of the barriers to use the recipes, although the recipes included a variety of preparation times with many recipes with preparation times under 10 minutes. This may be a specific problem for breakfast in case people do not usually spent much time to prepare these meals. Another barrier mentioned in the feedback forms was the portion size of the recipes. Some of the participants mentioned they thought the portion size was too big for breakfast. Another participant also mentioned they chose to not have them for breakfast because of a habit of having a small breakfast. This suggests the portion size may have been a specific barrier to not eat the dishes for breakfast. Large portion sizes could especially be a problem with the loss of appetite, i.e. the anorexia of ageing (Donini et al., 2003; Roy et al., 2016). It would be important to find combinations of foods that are appropriate and publicly acceptable for breakfast, in portions that are not thought to be too big. For future studies the advantages and limitations of using conventional foods for breakfast could be explored further.

If using only conventional foods for breakfast comes with too many barriers, a solution might lie in combining conventional foods with protein enriched foods. For

example, specific protein enriched foods that are similar to the breakfast/lunch foods older adults are familiar with, like yoghurts, smoothie drinks, bread, or adding protein powder to porridge or cereal. Older adults indicate that protein enriched foods are more easily accepted for breakfast if they are similar to their usual breakfast foods (Herrema et al., 2017). Finding protein enriched foods that are similar to familiar foods may facilitate increasing protein content of meals, with minimal changes to eating habits. Studies have significantly increased protein and energy intake for hospital patients using protein rich meals combining naturally protein rich foods and protein powder supplementation, taking into account patients' preferences and habits (Beermann et al., 2016; Bouillanne et al., 2013).

When looking at protein enrichment/fortification of foods, studies have focused specifically on the essential amino acid (EAA) leucine (Borack & Volpi, 2016). Increasing the leucine content of meals or protein drinks seems to overcome the anabolic resistance in older adults (Atherton et al., 2017; Katsanos, Kobayashi, Sheffield-Moore, Aarsland, & Wolfe, 2006; Rieu et al., 2006). Leucine is an EAA which is thought to play a part in how protein stimulates muscle protein synthesis (MPS) by activating anabolic signalling (Drummond & Rasmussen, 2008; Kimball & Jefferson, 2006). The threshold for Leucine dose to optimally stimulate MPS in older adults is suggested to be 2.5-3 g per meal (Bauer et al., 2013; Paddon-Jones & Rasmussen, 2009), which corresponds with 25-30g of high quality protein per meal. However, lower doses of leucine supplements have also been successful in stimulating MPS (Bukhari et al., 2015; Rieu et al., 2006). A recent review noted that a certain amount of protein is needed with the leucine to make sure other amino acids are available for MPS once it is activated by leucine (Wolfe, 2017). The dosage of added protein in enriched products needed to stimulate MPS would however still be lower, e.g. adding leucine to 6g of whey protein had the same effect on MPS as 25g of whey protein (Churchward-Venne et al., 2014). The taste of added protein can be an important barrier in the acceptance of protein enriched products (Tsikritzi, Moynihan, Gosney, Allen, & Methven, 2014). Finding the optimal dose of EAA needed to use in product enrichment with minimal changes to taste of familiar foods could therefore have a great impact on the acceptability of protein enriched foods, and consequently dietary protein intake in older adults.

Alternatively, if people prefer not to change habits for meals, maybe a protein enriched evening drink could be considered. Some British older adults may be used to have a traditional milk based drink before going to bed (e.g. Ovaltine or Horlicks).

A recent study has shown that protein enriched drinks before going to bed increased overnight MPS in older adults (Kouw et al., 2017). For those older adults who may not like to change their habitual meals and/or suffer from low appetite, changing their bed-time drink could be another option.

7.2.3 Target age range

The current research did not measure the effects of the intervention on older adults in terms of prevention or treatment. Although, older adults within the age range from 55 to 97 years old may show great differences in health status, physical ability, and lifestyle, as well as differences in preferences and eating habits (Keller & Engelhardt, 2013; Locher et al., 2009), this project used a general approach aimed to appeal to a wide age range, and potentially benefit a large group of older adults.

Chapter 4 and the baseline measures in chapter 5 suggest that under normal conditions, egg intake does not differ with age for individuals over 55 years old. After the intervention, age was not related to egg intake at T2. However, after the follow up period higher age was associated with higher egg intake at T3 (section 5.3.3). Chapter 6 showed that increase in egg intake in the intervention group was related to sarcopenia and low health related quality of life. If the increase in egg intake may be greater with higher age and for those with poorer health, this suggests younger and stronger/ more active individuals within this age range may benefit more from a different approach.

Although sarcopenia and other adverse health outcomes may be more prevalent with higher age (Keller & Engelhardt, 2013), this is not necessarily related to age (Bijlsma et al., 2013). For a study to measure whether the intervention was beneficial in terms of “prevention” or “treatment”, the participants should have been selected based on health status (e.g. frailty levels) as well. Moreover, a recent review by Phillips discussed focussing sarcopenia prevention studies on younger to middle age adults (Phillips, 2017).

New theories focus on the potential benefits of behaviour change in younger age groups to “prevent” (delay or slow down) sarcopenia in older age. Phillips recommends that “*older persons should aim to build up as much of a functional muscle mass (homeostatic reserve) as they can to provide a buffer against age-*

related sarcopenia" (Phillips, 2017). He implies that the relation between dietary protein intake and muscle mass may resemble the relation between calcium, vitamin D and bone, reducing the risk of osteoporosis/ osteopenia if adequate bone mass and density are acquired before age related loss (Phillips, 2017). Similarly, Robinson noted that muscle mass and strength at older age are affected by the peaks reached at younger age (Robinson, Cooper, & Aihie Sayer, 2012). Through anabolic resistance, ageing reduces the efficacy of protein intake (Breen & Phillips, 2011). Muscle mass is thought to start decreasing more rapidly around the age of 45 years old (Janssen, Heymsfield, Wang, & Ross, 2000; Phillips, 2017), but a meta-analysis by Morton et al (2017) shows most studies focus on people under 35 years old or over 55 years old. There seems to be a lack of studies with mean age between about 35 and 55 years old.

Paddon-Jones and colleagues suggest that while adults 40-65 years old may respond to muscle metabolism studies like the younger adults, periods of physiological stress (e.g. inactivity, injury, malnutrition) can promote anabolic resistance and increase muscle loss like in the older adults (English & Paddon-Jones, 2010; Paddon-Jones & Leidy, 2014). Unhealthy dietary habits, including higher saturated fat and lower fruit and vegetable intakes, in 42-52 year old women have been associated with greater functional limitations after a 4-year follow up (Tomey et al., 2008). The effects of dietary habits on future physical functioning on the long term are unknown, but these short term effects may suggest that eating and other health related behaviour at younger age might affect health and physical ability in older adults. For future research it may be important to focus on this younger age group, and increase dietary protein intake and muscle mass/strength in the decades before the age of 50 to delay or slow down age related loss of muscle strength and physical abilities at older age.

This does not mean nothing can be done at later age, muscle strength can increase even in very elderly people (Stewart, Saunders, & Greig, 2014). Sarcopenia is "*immanently amenable to treatment*" by physical activity as well as increased and/or evenly distributed protein intake (Phillips, 2017), but with anabolic resistance and decreased physical abilities it may be more challenging.

Different individuals may benefit from different approaches. Older adults with high total protein intakes like the participants of the trial in chapter 5, may benefit from optimizing the distribution of protein to increase the number of eating occasions they

reach the optimal protein intake threshold (Murphy et al., 2016). Malnourished elderly people with very low appetites and low intake of protein and total energy may not reach 25-30g of protein for any of their meals. Aiming for three meals with 25-30g could be unfeasible. However, it has been shown that older adults eating 30g of protein for one occasion per day, have significantly higher muscle strength and lean body mass than those not reaching 30g of protein for any eating occasions (Loenneke et al., 2016). Other researchers have expressed the importance for future research to focus on how to identify who would benefit from nutritional treatments (Beck, Beermann, Kjær, & Rasmussen, 2013). Future research could explore how to identify the optimal way to increase protein intake or number of eating occasions for different groups of older adults with different ages or health statuses.

7.2.4 Implications

Implications of the outcomes of this PhD project include that exposure to recipes could work to change egg consumption in older adults. People are exposed to recipes in everyday life in magazines, on food packages, available in supermarkets, or on television. This research has shown that providing recipes and herb/spice packets can change eating behaviour in older adults. If more recipes would be specifically designed to fit the preferences and habits of older adults, this could change the eating behaviour of many older adults. The current research has shown that adding variety and flavour to protein rich meals for older adults can increase intake. However, the research also showed that there are many reasons for eating or not eating eggs and that there are many individual differences. Because individual dietary advice for each individual older adult may not be feasible, segmentation and customizing recipes for groups of older adults could be considered in future research. The reasons found using the qualitative research and the questionnaire could potentially be used to identify groups/segments with similar determinants for egg consumption. Other factors that may be considered for future research include encouraging older adults to keep and reuse the recipes, and using staple/commonly eaten foods as part of the recipes.

7.3 Final summary

This PhD project has shown that older adults have many specific reasons for eating or not eating eggs, which was described in chapter 3. Some reasons were similar to determinants of egg consumption in younger adults, or to determinants of general eating behaviour in older adults, but some reasons are thought to apply specifically to egg consumption and older adults. Chapter 4 reports using the reasons that were identified in the focus groups to design a standardized questionnaire. The responses to this newly developed questionnaire were significantly related to egg consumption in a large National sample of adults aged 55 and over. Not only could the agreement/ disagreement with the different types of reasons predict egg intake, it also showed specific reasons which could differentiate between high and low egg consumers within the sample. Although several reasons were significant predictors of high egg consumption, the reasons based on flavour and variety were used to design an intervention study. Chapter 5 showed that the randomized controlled trial (RCT) was successful in increasing egg intake by sending the participants recipes and herb/spice packets through the post. The exposure to recipes was designed to mimic a real life setting, where the use of the recipes was not actively encouraged and foods were not provided. Unfortunately daily protein intake was not changed by the intervention, and change in lean body mass, physical performance and muscle strength was not related to the intervention. The wide range in egg intake and changes in egg intake show that there were large individual differences in how people responded to the intervention. Chapter 6 reports on exploratory further analyses on the data collected during the RCT, looking at which variables were related to change in egg intake, and reviewing feedback from participants on the intervention.

The current research has showed that exposing older adults to recipes and herb/spice packets can change their egg consumption, and may therefore be helpful in an easy to implement and cost effective strategy to change eating behaviour in older adults.

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9. Appendices

Appendix 3.1 – Focus group questioning route

INTRODUCTION

- Welcome + introducing
- For the discussion group I am interested in the reasons for eating or not eating foods in people > 55 years old.
- I try to include different types of people within this population, and you are invited because you are all (not) working.
- Questionnaire on reasons for food intake
- Thoughts and ideas very important, insightful, helpful for future research

- Audio recording
- Anonymity (names at the start)
- Confidentiality

- People talking a lot/not much
- No need to reach consensus or unanimity
- Don't hesitate to share different opinions
- Or straight forward answers
- No right or wrong answers

- I'm not here to inform about healthy eating
- I will ask questions but won't share my own opinions

DISCUSSION

- Can you please tell us your name, and tell us a little bit about the last meal that was particularly memorable?

"Thank you very much. Now we move to the group discussion, this means that you don't all have to answer the question in turn, but you can talk about it like a conversation. Please do try to talk one person at the time, so I can hear it on the recording later."

- Do you think your daily routine influences your eating?
    - How, if at all, do you think think your working hours/the fact that you are not working influences your eating?
    - How, if at all, do you think how active you are influences your eating?

- How, if at all, do you think your age influences your eating?

***PICTURES OF EGGS** - "I have several pictures of eggs prepared in different ways. These are just examples, for the following questions I will ask you to think of all the different ways in which you can eat eggs."*

- What do you think about eggs?
    - If you eat eggs, or eat them only in certain ways, what are your reasons to eat eggs?
    - Which factors influence whether you will eat eggs?

    - If you do not eat eggs, or do not eat them in certain ways, what are your reasons to not eat eggs?

PICTURES OF DIFFERENT FOODS (meat, fish, dairy, cheese, nuts, and pulses)

- I have pictures of several different foods, what do you think about these foods?
    - What are your reasons for eating or not eating these foods?

PICTURES OF DIFFERENT FOODS (meat, fish, dairy, cheese, nuts, and pulses)

- Do the mentioned reasons for (not) eating eggs differ between eggs and the foods in the pictures?
- Would you replace any of the foods in the pictures with egg?
- Would you replace any other foods with egg?

- Would you consider eating more eggs?
    - (People may ask if they can eat more, or are allowed to eat more? In that case, direct the question back to the group, and ask follow up questions in the context of *" If you would eat more eggs.."*.
    - How would you prefer to do that? (Add to meal or as a snack?)
    - What meal/time would you prefer?
    - How do you feel about trying new foods/recipes?

- Is there anything that should have been discussed but was not?

DEBRIEFING

- Sarcopenia (age-related loss of muscle mass and strength with the risk of physical disability and poor quality of life)
- Low dietary protein intake
- Protein-specific under-nutrition among older adults in UK
- Eggs --> high protein, soft texture, long shelf-life, and relatively easy cooking
- Intake of eggs among elderly in the UK is not high.

Appendix 3.2 – Themes and reasons

Hedonics
- Appeal
- Liking

Properties of the food
- Appearance
- Complete
- Flavour
- Freshness
- Moreish
- Odour
- Quality
- Satiating effect
- Size
- Texture

Preparation style
- Combination
- Processing

Convenience
- Convenience
- Culinary skills
- Effort to prepare
- Planning
- Practicalities
- Time to prepare

Physical environment
- Experience
- Availability
- Cost
- Financial situation
- Standby
- Value for money

Variety
- Replacing foods
- Variety
- Versatility
- Wide variety of choice

Food safety
- Food safety
- Food scares
- Spoilage and wastage

Physical health/abilities
- Appetite
- Digestibility
- Eating abilities
- Genes
- Medical factors
- Physical abilities
- Sensory abilities

Nutrition and health knowledge
- Balanced diet
- Health beliefs
- Nutritional knowledge
- Recommendations
- Restraint
- Sufficiency
- Value

Social environment
- Culture
- Other people present
- Politeness

Morality
- Animal welfare
- Environmental issues
- Food origins
- Moral values

Emotion
- Comfort
- Masculinity
- Status
- Treat

Habit
- Familiarity
- Habit
- Previous experience
- Substantial meals
- Staple food
- Suitability
- Trying new things
- Trend
- Upbringing

Appendix 3.3 – Definitions of reasons/sub-themes

Hedonics

- Liking = Liking or disliking for a food.
- Appeal = How appealing a food is, liking or disliking the idea of eating a certain food, usually without actually having eaten it.

Properties of the food

- Appearance = The appearance of a food (e.g. the colour, shape, or just general way it looks).
- Complete = A food being described as a meal in itself or a 'complete package'.
- Flavour = The taste and/or flavour of a food.
- Freshness = The freshness of foods, the time since a food has been obtained or the extent to which it is preserved.
- Moreish = When a food is referred to as being moreish, and people can easily eat a large amount of them, or struggle to stop from eating them once they started.
- Odour = The odour/smell of a food.
- Quality = The quality of a food, the extent to which a food is referred to as being e.g. better/worse, nicer, decent or proper.
- Satiating effect = The extent to which a food provides a satiating effect, or makes you feel full.
- Size = The size of a food.
- Texture = The texture or mouth-feel of a food.

Preparation style

- Combination = When foods are eaten or not eaten because it is served/eaten in combination with other foods which are liked or not liked, or if it is part of a dish or recipe that is eaten because people enjoy the whole dish, not because they want to eat each specific food.
- Processing = The amount of processing that went into a food before it is eaten (when served by others) or prepared at home.

Convenience

- Convenience = The general convenience of storing, preparing, or eating certain foods.
- Culinary skills = The ability or inability to cook or prepare a certain food.
- Effort to prepare = The effort it takes to prepare or cook a certain food.
- Planning = The extent to which preparing a food requires a certain amount of planning.
- Practicalities = When food choice or eating behaviour is determined by practical reasons that are not specified.
- Time to prepare = The time it takes to prepare or cook a certain food.

Physical environment

- Availability = The extent to how easily the food is accessible (this could be whether it is accessible in shops, or in the house, or within reach, or served to you).
- Cost = The price of foods, or relative cost compared to other foods.
- Experience = The whole experience or eating occasion itself influencing whether someone wants to eat a certain food or not.
- Financial situation = The influence of a person's financial situation on their food choice or eating behaviour.
- Standby = A food that is handy to have ready in case you need something to eat that was not planned.
- Value for money = the cost of a food in relation to the quality of a food.

Variety

- Replacing foods = Eating a food as an alternative for another food, or not eating it because you eat an alternative food.
- Variety = foods that are eaten or not eaten specifically to change the variety in the overall diet, from a hedonic point of view.
- Versatility = the extent to which a food can be eaten in different ways.
- Wide variety of choice = eating or not eating specific foods because of the variety of choice available.

Physical health/abilities

- Appetite = Changes in appetite, or appetite being different than it has been before.
- Digestibility = Any positive or negative influences digestion has on food choice or eating behaviour.
- Eating abilities = Physical abilities that are specific to eating, the ability or inability to eat certain foods, and effort it takes to eat a food (this includes chewing, biting, and swallowing difficulties).
- Genes = Genetic reasons that influence food choice or eating behaviour.
- Medical factors = Any medical reason that influences a person's food choice or eating behaviour.
- Physical abilities = Physical abilities or disabilities which influence food choice or eating behaviour (e.g. mobility).
- Sensory abilities = Abilities or disabilities of the senses (taste, smell, sight, hearing, and touch) that influence food choice or eating behaviour (including references to sensory deterioration with aging).

Nutrition and health knowledge

- Balanced diet = Foods that are eaten or not eaten specifically to balance out different foods as part of an overall diet, from a health and knowledge point of view.
- Health beliefs = Beliefs about a food that include any positive or negative value (e.g. good, bad or healthy, or the food being nutritious or beneficial, even if it is unclear whether this is in terms of energy (kcals) or nutrients or something else).

- Nutritional knowledge = Beliefs about a food including nutritional knowledge without giving a value of e.g. good, bad or healthy.
- Recommendations = Recommendations, advice, or reports concerning nutrition and health that can be positive or negative, and are provided by sources like e.g. media or health professionals. (Excluding negative media reports about food scares, e.g. the Salmonella scare.)
- Restraint = Actively avoiding certain foods, for different reasons including losing weight or health reasons.
- Sufficiency = A person's belief of eating enough of a certain food without giving any other reason of why they believe this specific amount is sufficient.
- Value = The belief that a food is beneficial (can be in terms of calories, or nutrients, or in general).

Food safety

- Food safety = Whether a food is safe or unsafe to eat, or references to a way of preparation that makes it more or less safe to eat.
- Food scares = Bacteria related food scares, that are known by most of the general public.
- Spoilage and wastage = Foods eaten because they are almost going off, or with other foods to prevent them from going off, or eating foods to prevent having to throw them away, or combined with other foods to prevent having to throw those foods away.

Social environment

- Culture = Cultural habits or traditions concerning a certain food.
- Other people present = The social influence of anyone present at an eating occasion on whether people eat something or not (e.g. people living in the same house, or guests). It could be that solely their presence influences food choice or eating behaviour, e.g. different foods served to guests than in a family situation, or it could be the preferences of the other people that are taken into consideration.
- Politeness = When food choice or eating behaviour are affected by wanting to be polite, or avoiding to be impolite.

Morality

- Animal welfare = Any type of animal welfare that is related to how a food is produced, and how the animals are kept.
- Environmental issues = Environmental issues (e.g. pollution) influencing people's food choice or eating behaviour.
- Food origins = The origin of the food, where the food comes from.
- Moral values = Any moral issues mentioned affecting food choice or eating behaviour.

Emotion

- Comfort = The comfort a food can offer, in terms of not providing negative feelings (e.g. guilt) or providing positive feelings (e.g. cheering up).
- Masculinity = Beliefs about gender specific eating behaviour.

- Status = The status eating or serving a certain food gives you (e.g. trying to impress people at a dinner party).
- Treat = A food that is eaten as a treat, to treat yourself or others.

Habit

- Familiarity = The extent to how familiar a person is with a certain food.
- Habit = Habitual behaviour concerning specific foods.
- Previous experience = A prior experience concerning the foods discussed, which is either a one off experience, something that happened in a set period of time, or something that never happened (excluding quotes about foods they have never eaten, as this would be coded as familiarity).
- Substantial meal = A food referred to as a snack food or a meal, or in terms of a lighter or a more substantial meal.
- Staple food = A food that is habitually bought on a regular basis.
- Suitability = Whether a food is considered suitable for a certain situation or combined with certain other foods, if it is eaten in a way that is suitable.
- Trying new things = Willingness to try new foods or types of foods.
- Trend = General eating behaviour from a specific period of time, or a certain food that was eaten by many people in a specific period of time.
- Upbringing = Eating behaviour and habits as a result of upbringing.

Appendix 3.4 – Quotes per reason

Theme	Reason	Quote
Hedonics	Appeal	"Pickled eggs, don't appeal to me at all. I can't say I've ever eaten them." (FG3)
	Liking	"I like a nice fried egg" (FG7) "I don't like the custard tarts at all." (FG5)
Properties of the food	Appearance	"I think eggs have an appearance going for them." (FG6)
	Complete	"It's all up in a little parcel and everything's there." (FG5)
	Freshness	"I do like fresh egg, lovely." (FG3)
	Odour	"And I'm also conscious of the fact that if I open up my lunchbox in the office, and I got egg sandwiches, then that office is going to smell in an unpleasant sort of way." (FG6)
	Quality	"I just, I want a decent egg." (FG6)
	Satiating effect	"I think they are quite filling as well. If you've had eggs for breakfast, you stay full for longer during the morning, than perhaps if you have a sugary cereal or something." (FG1)
	Size	"..people don't buy them [eggs] because they think they're too small." "But as long as it's large enough to fill what you want to make out of it, would it be a cake, you'd need a large egg, or maybe for an omelette you want 3 small eggs, that's fine." (FG4)
	Flavour	"..ducks eggs I do from time to time. Because they're bigger, and they are much more rich in taste." (I 2) "I think it's worth paying extra for the free range, the flavour is far superior." (FG6)
	Texture	"I mean you get a good texture with the scotch egg, for example, because you've got another component around the egg." (I 1)
	Moreish	"I think pistachios are dreadfully moreish once you start. You can just go on and on and on." (FG4)

Preparation style	Combination	"You wouldn't have an egg with a gin and tonic, would you? Where you can have a hand full of nuts." (FG4) "..in the summer we tend to eat more eggs, because I hard boil them and we have them with a salad. Which we don't tend to do in the winter." (FG1) "And partly the reason why I always have eggs is cause I like baking" (FG2)
	Processing	"I won't go for the devilled egg, cause I don't like sort of things where I don't know what the other ingredients are apart from the egg." (FG4)
Convenience	Convenience	"I have them [eggs] because they are very convenient, they are very easy to prepare." (FG1)
	Culinary skills	"..poached I don't like because I make a complete pigs ear of poaching them. I can't do it. So uh, I do enjoy a poached egg. But I won't prepare it for myself." (FG1)
	Effort to prepare	"I think a crème caramel is probably something that's not worth the effort of making." (FG5) "..an egg is very quick and easy to prepare.." (FG4)
	Planning	"I don't often have eggs in, because I'll have a couple of eggs with something and then not fancy them for ages, so they just sort of just sit in the cupboard, and they go out of date. So unless I've got something planned, and I know I'm going to use them up." (FG5)
	Time to prepare	"It's very very good, if you come in and you're hungry. They're very quick. That's why I eat them mostly." (FG1)
	Practicalities	"Omelettes are lovely if you make them yourself. .. If you had it yourself you cook it and eat it and then it's right. If it's sitting around waiting to be served, it goes hard. So I don't have them. I always have a poached one." (FG8)
Physical environment	Experience	"I like a fried egg, with a cooked breakfast on holiday." (FG7)
	Availability	"My husband often cooks a tortilla, the Spanish omelette. And it sits in the fridge, and you can't really open the door without having a piece." (FG3)
	Cost	"Actually that is another thing that's good about eggs. How cheap they are. You can make a meal cheaply with eggs." (FG1)
	Financial situation	"If it came down to physical cost, yes. If I just merely needed the protein and couldn't afford meat, and couldn't afford fish, yes I would eat egg." (FG7)

	Standby	“Also, it’s a good standby, eggs. If you get peckish at night, an egg sandwich, eggs on toast. It’s a good standby meal.” (FG7)
	Value for money	“I think it’s worth paying extra for the free range, the flavour is far superior.” (FG6)
Variety	Replacing foods	“I don’t tend to eat them for breakfast cause I have cereals..” (FG2)
	Variety	“If you have the same food on a regular basis, it becomes boring no matter how you dress it up. So you know, I wouldn’t eat eggs every other day, or such like.” (FG2)
	Versatility	“They’re very versatile aren’t they? You can use them in so many different ways.” (FG4)
	Wide variety of choice	“But just mentioning the different eggs in the supermarket so you can get quail eggs now, you can get duck eggs.” (FG6)
Physical health/abilities	Digestibility	“Yeah, it does have a detrimental effect doesn’t it, if you eat too many eggs?” (FG2) “I think the only thing it did with us is probably cut down the number we ate. Because of the concerns of what it might do to your constipation..” (FG4)
	Eating abilities	“There’s more to chew in meat, that’s where eggs and fish and that are much easier to eat.” (FG1)
	Genes	“Because we have a family history of not tolerating egg very well.” (I 1)
	Medical factors	“Because of the heart condition, I can’t have too many eggs.” (I 2)
	Physical abilities	“And they do repeatedly put them [eggs] on a high shelf. So you’re frightened they’re gonna break when you, when you try to reach them.” (FG1)
	Sensory abilities	“I mean I tried a boiled egg the other day and I just think your taste changes over the years.” (FG7)
	Appetite	“If your appetite is not, you can’t eat the quantity that you used to eat when you were younger. Then, certainly in my case, I eat what I call more of the good stuff. It’s sort of like a Sunday lunch, roast and meat and two veg. I would miss out the vegetables, and the potatoes, or just have a very small amount. But I’ll have a bigger portion, big portion of the main thing, the meat, or whether it’s fish, or whatever, and have very little with it. I think traditionally you used to have just a little bit of meat and then you’d have a lot of potato and vegetables, because that was on a cost point of view, that’s what people did. But now I forget about all the peripheral stuff and just have the really good stuff.” (FG1)

Nutrition and health knowledge	Balanced diet	“They [eggs] are protein and that’s fine. It’s not a meat meal but at least I’ve had some protein.” (FG2)
	Health beliefs	“I wouldn’t go for a fried egg, because I don’t think that’s healthy.” (FG4)
	Nutritional knowledge	“And it’s [egg is] a good protein to have first thing in the morning, cause it’s a protein. And therefore you stay fuller for longer.”
	Recommendations	“They keep changing their minds about health advice and when my husband had heart surgery, he was told only to have one egg a week. And then a few years later they changed their minds, and said it didn’t matter.” (FG1) “I started to include more eggs than before. Cause actually now the research on egg fat has changed. And you can have lots of eggs. And if you’re diabetic, that’s fine. You can have eggs, you can have eggs every day.” (FG7)
	Restraint	“Because I have to watch the calorie content of what I eat. That would limit how many eggs.” (FG5)
	Sufficiency	“I think I eat enough eggs in the week to be sufficient.” (FG2)
	Value	“..in 3 minutes you’ve got a very nutritious meal.” (FG6)
Food safety	Food safety	“My eggs sit on the side, I don’t keep ‘em in the fridge and I never look at the dates, never have. And I’ve never been ill from an egg, so. It’s never worried me” (FG2) “I think the production of eggs is very very carefully monitored..” (FG2) “I suppose if they’re cooked properly, I mean it was things like soft boiled eggs. It was if they were cooked I think, I suppose it killed the salmonella.” (I 1)
	Food scares	“So that maybe the Edwina curry fall out, we’re still a little suspicious of raw egg, as opposed to cooked egg” (FG4) “I think the salmonella scare put a lot of people off raw eggs.” (FG1)
	Spoilage/ Wastage	“And I also had hard boiled eggs, about a week ago. Because I needed to use them up. Because they had got to their sell by date. So I hard boiled them.” (FG1) “If you’ve got bread that’s a bit past it’s sell by date. You can make French toast, which is lovely. I often have French toast.” (FG1)
Social environment	Culture	“Because I’m Portuguese and we have chorizo and omelette all the time.” (FG3) “It’s a north country thing, pickled eggs.” (FG7)
	Other people present	“I think if you’re having people round, eggs probably wouldn’t be a first choice. It would be more of a perhaps just a family thing, or even if you’re on your own type thing.” (FG4) “Well, I like any eggs, but me partner likes boiled eggs.” (FG6)

	Politeness	“So I couldn’t tell her that I didn’t like it [omelette], cause I felt that wasn’t the right thing to do.” (FG2)
Morality	Animal welfare	“Well just because, an egg is an egg. And I buy the free range eggs because of sympathies to animal welfare and all that sort of thing.” (FG6)
	Food origins	“I’d rather know where they came from rather than how cheap they are.” (FG4)
	Environmental issues	“If it was, if I could buy a packet of peas coming from Norfolk, and a packet of peas coming from Kenya, I would buy the ones from Norfolk. That’s the sort of choice we make. Carbon footprint I suppose.” (FG6)
	Moral values	“Obviously there’s an on-going debate about eating meat from the point of view of us in the west, or in the wealthy part of the world, consuming too much. So that if there were more vegetarians around, there would be a more even dispersal of the world’s resources and there wouldn’t be so many starving people.” (FG6)
Emotion	Comfort	“So I think there’s a lot of comfort in an egg, because I feel very guilty about eating things that I shouldn’t eat. And with an egg, I can eat it, so I have a lot of eggs.” (FG5)
	Masculinity	“And real men don’t eat quiche.” (FG3) “An egg is dead easy, anybody can cook an egg. It doesn’t need a lot of education. Perhaps that’s the appeal to men, I don’t know.” (FG6)
	Status	“..it’s like whether you want to try and impress or whether you just want to give somebody a healthy meal. Just something that you’d rather make an effort out of.” (FG4) “You know if you come up with an omelette you know, dumped in the middle of a plate with a slice of tomato next to it, they’re not gonna be that impressed. Whereas something like that, or something with the fish.. And also they would know that you’ve hardly taken any time. You know, you haven’t devoted that much time to it. Sort of hospitality etcetera.” (FG6) “I think if you’re having people round, eggs probably wouldn’t be a first choice.” (FG4)
	Treat	“And having a fried egg and a bit of bacon, sausage and that, you got to take a bit of time on it. So it’s the thing that you would use as a treat.” (FG6)

Habit	Familiarity	“I never had an omelette, just a plain omelette.” (FG3)
	Habit	“I start everyday normally with eggs.” (FG3)
	Previous experience	“And I’ve never been ill from an egg..” (FG2)
	Substantial meals	“It would be a snack food, egg, rather than a substantive meal.” (FG2) “I’ll make egg sandwiches, but again it comes into that snack category. I wouldn’t replace my main meal with eggs.” (FG5)
	Staple food	“To me they’re part of the staple food basket each week.” (FG2)
	Suitability	“Although if you have it the wrong time of day, if you had a boiled egg for tea for example whereas we normally have a proper meal then I would feel short changed. If you had it for breakfast or for lunch maybe, then that’s ok.” (FG5) “..I can remember that in me 20s, you went for a night out in the pub and you had a pickled egg and a package of crisps.” (FG7)
	Trend	“Egg mayonnaise used to be quite a popular thing didn’t it, at one time?” (FG5)
	Trying new things	“Perhaps I need to experiment more because now we live in an age of choice where you can go into a supermarket and buy 300 different types of egg.” (FG6)
	Upbringing	“My mum used to do those stuffed eggs, or devilled eggs. And I actually do them now, if we do put on a birthday I do it.” (FG3)

*FG = focus group, e.g. FG1 means focus group number 1. I = interview, e.g. I1 means interview number 1.

Appendix 3.5 – Number of references and sources for each reason/sub-theme

Themes	Sub-themes	Sources coded	Units of meaning coded
Hedonics			
	Appeal	6	21
	Liking	10	89
Properties of the food			
	Appearance	6	22
	Complete	4	4
	Flavour	9	38
	Freshness	4	10
	Moreish*	2	2
	Odour	2	2
	Quality	8	20
	Satiating effect	6	15
	Size	3	5
	Texture	8	16
Preparation style			
	Combination	10	94
	Processing	5	8
Convenience			
	Convenience	8	32
	Culinary skills	3	3
	Effort to prepare	9	36
	Planning	1	1
	Practicalities	1	1
	Time to prepare	9	37
Physical environment			
	Experience	3	3
	Availability	10	44
	Cost	7	19
	Financial situation	4	6
	Standby	5	9
	Value for money	5	8
Variety			
	Replacing foods	4	6
	Variety	4	10
	Versatility	6	10
	Wide variety of choice	2	2

Physical health/abilities			
	Appetite*	1	1
	Digestibility	3	7
	Eating abilities	2	4
	Genes	1	1
	Medical factors	3	9
	Physical abilities	2	2
	Sensory abilities	1	3
Nutrition and health knowledge			
	Balanced diet	4	6
	Health beliefs	8	37
	Nutritional knowledge	9	19
	Recommendations	8	27
	Restraint	7	17
	Sufficiency	6	11
	Value	4	8
Food safety			
	Food safety	4	7
	Food scares	4	6
	Spoilage and wastage	5	14
Social environment			
	Culture	2	5
	Other people present	7	11
	Politeness	1	2
Morality			
	Animal welfare	6	15
	Environmental issues*	1	2
	Food origins	8	19
	Moral values*	1	2
Emotion			
	Comfort	2	2
	Masculinity	2	2
	Status	4	6
	Treat	3	7
Habit			
	Familiarity	3	5
	Habit	6	35
	Previous experience	3	5
	Substantial meals	8	36
	Staple food	4	6
	Suitability	8	19
	Trying new things	3	5
	Trend	6	11
	Upbringing	7	15

*Reasons including quotes about protein rich foods, other than egg.

Please indicate how often and when you normally eat or drink each of the following foods by placing a tick in the appropriate box. Please tick the answer that applies best.

When do you normally eat it? Please tick all options that apply.

	more than once a day	more or less daily	3-5 days a week	1-2 days a week	1-3 days a month	less than monthly	never	break-fast	lunch	evening meal	snack
White meat (e.g. chicken, turkey)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Red meat (e.g. beef, lamb, pork)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Processed meats (e.g. ham, bacon, sausages, corned beef)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
White fish (e.g. cod, haddock)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Oily fish (e.g. sardines, salmon)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Seafood (e.g. prawns, mussels, crab)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Eggs and egg dishes	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Vegetarian meat-substitute (e.g. Quorn)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Milk (excluding milk in tea/coffee)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Milk in coffee or tea	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Yoghurt, custards, blancmanges, etc.	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Hard cheeses (e.g. Cheddar, Stilton)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Soft cheeses (e.g. cream cheese, brie, cottage cheese)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Nuts and seeds	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Pulses (e.g. lentils, Dahl)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Beans or peas	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Bread (e.g. white or whole meal)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Breakfast cereals or porridge	☐	☐	☐	☐	☐	☐	☐	O	O	O	O

Now I would like to ask you a few questions about how often and when you eat the following types of eggs or egg dishes. Please place a tick in the appropriate box.

When do you normally eat it? Please tick all options that apply.

	more than once a day	more or less daily	3-5 days a week	1-2 days a week	1-3 days a month	less than monthly	never	break-fast	lunch	evening meal	snack
Boiled eggs (hot)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Hard boiled eggs (cold)	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Fried eggs	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Scrambled eggs	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Poached eggs	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Omelettes	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Scotch eggs	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Quiches/ savoury flans	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Egg mayonnaise	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Egg sandwiches	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Egg salad	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Custards	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Meringues	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Sweet flan / Crème caramel	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Duck/Quail's eggs	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Raw eggs	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
I deliberately eat/use the yolk separate from the white	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
I deliberately eat/use the white separate from the yolk	☐	☐	☐	☐	☐	☐	☐	O	O	O	O
Other ……..	☐	☐	☐	☐	☐	☐	☐	O	O	O	O

The next statements are all about eggs. Please indicate how much you agree or disagree with them, even if you do not eat eggs. Please tick the box of the answer that applies best.	strongly disagree	disagree	neither disagree nor agree	agree	strongly agree
I never eat eggs with other foods.					
Eggs are convenient for me.					
I think eggs go off quickly.					
I take recommendations about eating eggs from newspapers and the radio very seriously.					
Preparing eggs is not practical.					
I think eggs smell nice.					
I would not serve eggs at a dinner party.					
Eggs take a lot of effort for me to prepare.					
Eggs are really quick to prepare.					
I think eating eggs is manly.					
I think egg consumption is bad for the environment.					
Eggs do not appeal to me.					
There were not many eggs around when I was younger.					
It is important to me to know how my eggs are prepared.					
I eat eggs regardless of media reports about salmonella.					
Many people used to eat eggs when I was younger.					
I eat eggs out of politeness.					
I was not brought up eating eggs.					
I would consider eating more eggs than I do currently.					

How much do you agree or disagree with the following statements? Please tick the box of the answer that applies best.	strongly disagree	disagree	neither disagree nor agree	agree	strongly agree
I never try out new recipes with eggs.					
Eating eggs is part of my culture.					
When I start eating eggs, I never want to stop.					
I think eggs are filling.					
I think eggs are very versatile.					
I have a family history of problems after eating eggs.					
Eggs are a comfort food for me.					
I eat eggs when it is a particular occasion, e.g. on holiday.					
I think eggs are a good standby.					
I do not eat eggs because of a medical condition.					
I think eating eggs is beneath me.					
I know why eggs can be good or bad for health.					
I think eggs look nice when they are ready to eat.					
It is important to me that the eggs that I eat are fresh.					
Eating eggs is not part of my routine.					
I only eat eggs when they are properly cooked.					
I think eating eggs is feminine.					
I think eggs are unhealthy.					
I have no physical disabilities that hinder me from preparing eggs.					

How much do you agree or disagree with the following statements? Please tick the box of the answer that applies best.	strongly disagree	disagree	neither disagree nor agree	agree	strongly agree
I can cook eggs.					
I limit the amount of eggs I eat because of the cholesterol.					
I think eggs have a nice consistency.					
Eggs add variety to my diet.					
I think eggs are cheap.					
I think eggs are nutritious.					
Eggs are easy for me to digest.					
In my opinion there are certain meals or situations where eating eggs is more appropriate than in other situations.					
I have had bad experiences with eggs in the past.					
Eggs are a staple food for me.					
I eat eggs regardless of what my friends and family recommend.					
I eat eggs because other people in my house want to eat them.					
Preparing eggs does not need a lot of planning for me.					
I think eggs increase the risk of heart diseases.					
It is important to me that eggs are free range.					
The range of eggs where I shop is good.					
I think eggs are a compact little parcel.					
The quality of the eggs that I eat is important to me.					
I would consider replacing other foods in my diet with eggs.					

How much do you agree or disagree with the following statements? Please tick the box of the answer that applies best.	strongly disagree	disagree	neither disagree nor agree	agree	strongly agree
There are some egg dishes I have heard of but have never tried.					
I find eggs difficult to chew and swallow.					
I think eggs are part of a balanced diet.					
I think eggs taste good.					
I think eggs are a good snack food.					
I only eat eggs when they are served to me and I do not have to prepare them myself.					
Eggs have begun to taste different to me as I have got older.					
I think eggs are good value for money.					
I eat eggs regardless of what health professionals recommend.					
I try to limit the number of eggs I eat.					
I eat eggs often because my income is not very high.					
I always have eggs around.					
The size of the eggs I use does not matter to me (Small/Medium/Large).					
I like eggs.					
I have physical disabilities that hinder me in shopping for eggs (e.g. reaching shelves).					
I am still able to eat as many eggs as when I was younger.					
If more people in the world ate eggs, less people in the world would be starving.					
Eggs are a treat for me.					
It is important to me to know where eggs come from.					

What is your favourite type of egg? (Please pick one type. For options see page 2)

.....

Please think about your favourite type of egg indicated above. How much do you agree or disagree with the following statements?	strongly disagree	disagree	neither disagree nor agree	agree	strongly agree
I think my favourite type of egg tastes good.					
My favourite type of egg is a comfort food to me.					
Preparing my favourite type of egg does not need a lot of planning for me.					
I can cook my favourite type of egg.					
My favourite type of egg is really quick to prepare.					
My favourite type of egg is a treat for me.					
My favourite type of egg takes a lot of effort for me to prepare.					
When I start eating my favourite type of egg, I never want to stop.					
I think my favourite type of egg smells nice.					
I think eating my favourite type of egg is feminine.					
Preparing my favourite type of egg is not practical.					
I think my favourite type of egg is filling.					
I never eat my favourite type of egg with other foods.					
It is important to me to know how my favourite type of egg is prepared.					
I think eating my favourite type of egg is manly.					
My favourite type of egg is convenient for me.					
I think my favourite type of egg has a nice consistency.					
I think my favourite type of egg looks nice.					
I would not serve my favourite type of egg at a dinner party.					

The next few questions will be about your physical abilities and other life style factors. Please answer with the category that applies best.

1. **Do you have difficulties with any of these activities: lifting and carrying 10 lbs. (5 bags of sugar), walking across a room, transferring from a chair or bed, or climbing a flight of 10 stairs?**
   - o No
   - o Some difficulties with some of these activities
   - o Some difficulties with all of the above activities
   - o A lot of difficulty with some of these activities
   - o A lot of difficulty with all of the above activities
   - o I am unable to do these things

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2. How much do you agree with the following statements?	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
- I am constantly sampling new and different foods.	☐	☐	☐	☐	☐
- I don't trust new foods.	☐	☐	☐	☐	☐
- If I don't know what is in a food, I won't try it.	☐	☐	☐	☐	☐
- I like foods from different countries.	☐	☐	☐	☐	☐
- Foreign food looks too weird to eat.	☐	☐	☐	☐	☐
- At dinner parties, I will try a new food.	☐	☐	☐	☐	☐
- I am afraid to eat things I have never had before.	☐	☐	☐	☐	☐
- I am very particular about the foods I will eat.	☐	☐	☐	☐	☐
- I will eat almost anything.	☐	☐	☐	☐	☐
- I like to try new foreign restaurants.	☐	☐	☐	☐	☐

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3. Do you..	Never	Sometimes	Often
.. receive help with food shopping because you struggle?			
.. receive help with food preparation because you struggle?			
.. eat out or away from your home?			
.. get food delivered?			

4. **Do you have any allergies to eggs?**
   - o No
   - o Yes
5. **Have you had any condition or treatment in the last 6 months that changed your eating behaviour a lot (e.g. chemo-/radio therapy)? And if yes, please provide detail below.**
   - o No
   - o Yes
6. **Is there anything else you would like to add about eggs and the other foods in this questionnaire? Please comment below before moving to the final page.**

Lastly, the next questions will be about you. Please give the answer that applies best.

7. **Which age group applies to you?**
   - ○ 55-59 years old
   - ○ 60-64 years old
   - ○ 65-69 years old
   - ○ 70-74 years old
   - ○ 75-79 years old
   - ○ Over 80 years old

8. **Are you male or female? ……..……..…**

9. **What was your last measured height? …….....**

10. **What was your last measured body weight? ……..……..…**

11. **What is the first half of your current post code? ...……..……..……..**
    (I will use this only to check I have respondents from all over the UK.)

12. **What is your marital status? (Please tick one answer.)**
    - ○ I am married or remarried
    - ○ I am divorced
    - ○ I am widowed
    - ○ I have never married

13. **What is your nationality? ……..……..…**

14. **Do you live by yourself?**
    - ○ I live by myself
    - ○ I live with another person/others

15. **How many years of full time education have you received? (e.g. if you attended school from the ages 5 to 16 years, you have received 12 years of education.)**
    ……..

16. **What is your most recent level of employment? (If you are retired, what was your level of employment before you retired?)**
    - ○ Unemployed (e.g. housewife, or stay-at-home dad)
    - ○ Manual worker (e.g. builder, or shop assistant)
    - ○ Non-manual worker (e.g. secretary, or teacher)
    - ○ Professional or management (e.g. doctor, or accountant)

17. **Do you wear dentures?**
    - ○ No
    - ○ Yes, partial dentures
    - ○ Yes, full dentures

Thank you very much for taking the time to help me with my research, I really appreciate it.

Appendix 4.2 – Participant characteristics: demographic characteristics and lifestyle factors

Participant characteristics (N = 230)

Characteristic	Value
Region*	
Scotland	11 (4.7%)
Northern Ireland	5 (2.2%)
North East	6 (2.6%)
North West	22 (9.5%)
Yorkshire and the Humber	21 (9.1%)
East Midlands	18 (7.8%)
West Midlands	14 (6.0%)
Wales	9 (3.9%)
East of England	17 (7.3%)
London	17 (7.3%)
South East	35 (15.1%)
South West	53 (22.8%)
Receiving help with food shopping*	
Never	200 (86.2%)
Sometimes	19 (8.2%)
Often	9 (3.9%)
Receiving help with food preparing*	
Never	203 (87.5%)
Sometimes	17 (7.3%)
Often	8 (3.4%)
Eating out or away from home*	
Never	12 (5.2%)
Sometimes	145 (62.5%)
Often	68 (29.3%)
Getting food delivered*	
Never	162 (69.8%)
Sometimes	55 (23.7%)
Often	11 (4.7%)
Physical disabilities*	
No	169 (72.8%)
Some difficulties with some activities	33 (14.2%)
Some difficulties with all activities	10 (4.3%)
A lot of difficulty with some activities	7 (3.0%)
A lot of difficulty with all activities	4 (1.7%)
Unable to do them	1 (0.4%)
Food Neophobia score (Mean $\pm$SD)	25 $\pm$ 7

* Frequency and percentage are given. For several variables the numbers do not add up to n=230 because different people left different questions open. They were not excluded because the power would get too low. They were excluded pair-wise in the regression analyses.

Appendix 4.3 – Representability of subject characteristics

Chi squared test on participant characteristics (age group, gender and region) comparing the study sample to the expected sample based on Census 2011 (N = 230).

Characteristic	Observed percentages in study sample	Expected percentages (based on CENSUS 2011)	χ^2	P value per category	P value per characteristic
Age*					
55-59 years old	13.91%	20.3%	5.80	P < .05	
60-64 years old	16.52%	21.4%	3.25		
65-69 years old	23.48%	17%	6.84	P < .01	P < .01
70-74 years old	20.87%	13.8%	9.66	P < .01	
75-79 years old	15.65%	11.3%	4.35	P < .05	
80+ years old	9.57%	16.2%	7.46	P < .01	
Gender*					
Male	51.74%	46.3%	2.74		
Female	47.83%	53.7%	3.19		
Region*					
Scotland	4.78%	8.8%	4.63	P < .05	
Northern Ireland	2.17%	2.6%	0.16		
North East	2.61%	4.4%	1.75		
North West	9.57%	11.4%	0.77		
Yorkshire and the Humber	9.13%	8.5%	0.12		P < .01
East Midlands	7.83%	7.5%	0.04		
West Midlands	6.09%	9%	2.38		
Wales	3.91%	5.4%	1.00		
East of England	7.39%	9.8%	1.51		
London	7.39%	9.1%	0.81		
South East	15.22%	14.1%	0.24		
South West	23.04%	9.7%	46.75	P < .01	

Appendix 4.4 – Principal Component Analysis: Definitions of the components

Overview of the components generated using the Principal Component Analysis (PCA). Per components the reasons are given, and a definition of the component.

Component	Included reasons	Definition
21. Liking, flavour, variety	- Variety - Balanced diet - Flavour - Liking	Whether people like the taste of eggs, and thinks it adds variety to the diet (in terms of taste).
22. Value for money	- Spoilage and wastage (R) - Versatility - Standby - Cost - Value - Planning - Complete - Substantial meal - Value for money - Financial situation (R) - Nutritional knowledge	Whether people think eggs provide good value for the money you pay for it, including it being a good value food, which is cheap and does not go off quickly, (not wanting to waste money).
23. Food chain	- Processing - Freshness - Animal welfare - Wide variety of choice - Quality - Food origin	The importance of knowing about the food chain the egg goes through, from chicken (animal welfare), to shops, to your plate. And the quality/freshness of the egg as a result of it.
24. Everyday food	- Convenience - Satiating effect - Habit (R) - Staple food - Recommendations friends/family - Digestibility	Whether people think eggs are a convenient filling staple food and eat them habitually (including how much this is affected by recommendations of family and friends).
25. Effort	- Practicalities - Effort to prepare - Politeness - Health beliefs - Culinary skills - Eating abilities - Availability served by others	Whether people think eggs take a lot of effort to prepare, or eat, and would be eaten out of politeness or just when it is served by others. Also, including how healthy they think eggs are.
26. Previous experience	- Genes - Previous experience - Medical factors general	Whether people have had a bad experience in the past, or a family history of problems related to eating eggs, or a medical condition that restricts them from eating eggs.
27. Past	- Trend availability - Trend popular (R) - Upbringing	Whether people had many eggs around, and remember many people eating them in the past, and/or being brought up with eggs.

28. Occasion	-	Comfort Experience	Whether people eat eggs when there is a particular occasion.
29. Stereotypes	-	Masculinity Environmental issues Status personal Masculinity fem	Amount of agreement with stereotypes or perceptions about a type of person, regarding eating eggs.
30. Sensory	-	Odour Appearance Texture	Whether people think the sensory aspects of eggs are nice.
31. Expectations	-	Combination Status guests Appeal	How eggs are expected to be eaten in certain circumstances. (Whether they eat eggs with other foods or have a problem serving eggs at a dinner party.)
32. Willingness to eat more eggs	-	Sufficiency Replacing foods	Having clear ideas about what amounts/portions of eggs are enough. Willingness to add more eggs to their diet.
33. External reports	-	Recommendations media Food scares (R) Recommendations health professionals (R)	How serious you would take external reports and recommendations about eggs and health
34. Eating less with aging	-	Appetite (R) Sensory abilities Restraint Physical abilities shopping Physical abilities preparing (R)	Whether people suffer from different struggles/problems that may occur when getting older, like physical abilities hindering shopping or preparing foods, or loss of appetite or sensory deterioration.
35. Medical factors	-	Medical factors cholesterol Medical factors heart disease	Whether people believe eating eggs increases cholesterol or risk of heart disease.
36. Moreish	-	Moreish	Whether people perceive eggs as moreish.
37. Suitability	-	Suitability	How suitable eating eggs is in a certain context, situation, time, dish etc. Ideas on how you are supposed to eat them.
38. Familiarity	-	Familiarity	Whether there are certain egg dishes people have never tried.
39. Size	-	Size	Whether the size of eggs matters.
40. Food Safety	-	Food safety	How perceived food safety affects egg intake. Level of agreement to only eating eggs when they are properly cooked.

*All items ending with (R) were reverse scored, because they had a negative component loading in the PCA.

Appendix 4.5 – Multiple linear regression results – demographic characteristics and lifestyle factors

Multiple linear regression model with demographic characteristics and lifestyle factors as independent variables predicting egg intake.

	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	18.924	12.882		1.469	.143	-6.482	44.330					
Protein intake	.068	.015	.311	4.534	**.000**	.038	.097	.233	.309	.295	.901	1.110
Physical abilities score	1.288	1.381	.088	.932	.352	-1.436	4.011	.047	.067	.061	.475	2.104
Food neophobia	-.176	.138	-.089	-1.273	.204	-.447	.096	-.091	-.091	-.083	.857	1.167
Help food shopping	-1.225	2.871	-.043	-.427	.670	-6.887	4.437	-.005	-.031	-.028	.422	2.369
Help food preparation	-3.353	2.431	-.111	-1.379	.169	-8.147	1.441	-.059	-.098	-.090	.652	1.533
Eat away from home	.694	1.666	.028	.417	.677	-2.591	3.979	.057	.030	.027	.917	1.090
Food delivered	1.104	1.654	.047	.668	.505	-2.157	4.366	.071	.048	.043	.854	1.171
Age group	-1.230	.664	-.140	-1.852	.066	-2.539	.080	-.079	-.131	-.120	.742	1.347
Gender	-2.173	1.821	-.082	-1.193	.234	-5.763	1.418	-.053	-.085	-.078	.903	1.107
BMI	.421	.176	.166	2.398	**.017**	.075	.767	.153	.169	.156	.887	1.127
Region code	-.200	.260	-.053	-.769	.443	-.712	.313	-.053	-.055	-.050	.887	1.128
Marital status	.464	1.250	.034	.371	.711	-2.002	2.929	.066	.027	.024	.493	2.030
Living status	-2.511	2.804	-.086	-.896	.372	-8.041	3.019	-.060	-.064	-.058	.461	2.169
Education	-.851	.406	-.158	-2.096	**.037**	-1.652	-.050	-.112	-.148	-.136	.743	1.346
Employment level	.518	1.121	.034	.462	.644	-1.693	2.730	.008	.033	.030	.783	1.276
Denture wearing	2.754	1.561	.129	1.764	.079	-.325	5.832	.074	.125	.115	.792	1.262

Appendix 4.6 – Multiple linear regression results – Principal Component Analysis components

Multiple linear regression model with PCA components, and protein intake, BMI, and denture wearing as independent variables predicting egg intake.

	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	-5.396	17.741		-0.304	0.761	-40.373	29.581					
Liking/Flavour/Variety	1.360	0.569	0.224	2.391	**0.018**	0.239	2.481	0.279	0.164	0.138	0.378	2.645
Value for money	-0.597	0.264	-0.182	-2.261	**0.025**	-1.117	-0.076	0.074	-0.156	-0.130	0.511	1.957
Food chain	0.241	0.253	0.065	0.954	0.341	-0.257	0.740	0.130	0.066	0.055	0.707	1.415
Everyday food	0.774	0.305	0.204	2.542	**0.012**	0.174	1.375	0.289	0.174	0.146	0.515	1.942
Effort	-0.519	0.353	-0.122	-1.471	0.143	-1.215	0.177	-0.148	-0.102	-0.085	0.481	2.079
Previous experience	0.805	0.568	0.104	1.417	0.158	-0.315	1.925	0.008	0.098	0.082	0.615	1.627
Past	-0.098	0.364	-0.018	-0.271	0.787	-0.816	0.619	-0.009	-0.019	-0.016	0.770	1.299
Occasion	0.447	0.561	0.055	0.797	0.426	-0.659	1.554	0.134	0.055	0.046	0.707	1.415
Stereotypes	-0.911	0.427	-0.151	-2.133	**0.034**	-1.753	-0.069	-0.109	-0.147	-0.123	0.658	1.521
Expectations	0.529	0.462	0.083	1.145	0.254	-0.382	1.440	-0.122	0.079	0.066	0.624	1.603
Willingness to eat more eggs	-1.303	0.600	-0.141	-2.174	**0.031**	-2.485	-0.121	0.014	-0.150	-0.125	0.790	1.266
External reports	-0.600	0.457	-0.092	-1.314	0.190	-1.501	0.300	-0.156	-0.091	-0.076	0.680	1.471
Moreish	2.918	0.967	0.194	3.017	**0.003**	1.011	4.824	0.211	0.206	0.174	0.801	1.248
Medical factors	-0.893	0.568	-0.108	-1.572	0.117	-2.013	0.227	-0.119	-0.109	-0.091	0.708	1.413
Suitability	-0.401	0.884	-0.028	-0.454	0.650	-2.145	1.342	0.015	-0.032	-0.026	0.891	1.122
Familiarity	-0.600	1.099	-0.033	-0.546	0.586	-2.767	1.567	-0.027	-0.038	-0.031	0.892	1.121
Size	-0.406	0.734	-0.034	-0.554	0.580	-1.853	1.040	0.000	-0.039	-0.032	0.902	1.109
Food safety	-0.875	0.936	-0.060	-0.935	0.351	-2.721	0.970	-0.088	-0.065	-0.054	0.817	1.224
Sensory	0.289	0.571	0.037	0.506	0.614	-0.837	1.415	0.194	0.035	0.029	0.627	1.594
Eating less with aging	1.032	0.390	0.213	2.648	**0.009**	0.264	1.801	-0.001	0.181	0.153	0.514	1.946
Protein intake	0.052	0.013	0.237	3.894	**0.000**	0.026	0.078	0.233	0.262	0.224	0.892	1.121
BMI	0.449	0.160	0.172	2.800	**0.006**	0.133	0.765	0.149	0.191	0.161	0.879	1.137
Education	-0.403	0.348	-0.073	-1.158	0.248	-1.090	0.283	-0.104	-0.080	-0.067	0.827	1.209

Appendix 5.1 – Dietary information postcard

Bournemouth University

Did you know that many people in your age group would benefit from higher protein intake?

The human body is constantly building muscle, while at the same time muscle tissues are broken down.

As people get older it can be difficult to retain the balance, because more muscle tissue is broken down than new muscle is formed. This imbalance results in muscle loss, and eventually people become frail.

To maximize muscle building, 25-30 grams of protein per meal is recommended.

Currently, many people do not eat this amount of protein for each meal of the day. Breakfast especially seems to be a meal when many people do not eat enough protein to maximize muscle building.

Foods high in protein are: meat, fish, eggs, dairy products, nuts, beans and other pulses.

Appendix 5.2 – List of recipes per week

Week 1	Week 2
Cheese and ham eggy bread	**Salmon scrambled egg** - Dill
Spinach, feta and pine nut omelette	**Ham and egg cobbler**
Egg cupcakes - Chives	**Croque Madame**
Tuna and broccoli omelette	**Mushroom and goat's cheese tortilla** - Thyme, chives
Fried egg naan with masala beans - Garlic, ginger, garam masala, coriander	**Buck rarebit** - Mustard powder
Baked eggs with goat's cheese on ciabatta - Parsley, mint	**Turkish eggs with Turkish toast** - Paprika
Week 3	**Week 4**
Moroccan spiced eggs and tomatoes with a minted yoghurt - Cumin, coriander, chilli	**Turkish Scrambled eggs** - Paprika, oregano, parsley, dill, mint
Pizza omelette - Chives	**Smoked mackerel scramble** - Chives
Salmon and watercress frittata	**Special dippy eggs and soldiers**
Leftover roast chicken crust less mini quiches - Thyme, rosemary	**Smoked salmon and asparagus omelette**
Eggs Florentine - Hollandaise sauce mix	**Indian omelette** - Garam masala, cumin, curry powder, coriander
Chinese fried eggs	**Pesto egg and ham Danish pastry**
Week 5	**Week 6**
Huevos rancheros - Coriander	**Masala scrambled eggs** - Cumin, chives, coriander
Breakfast wrap	**Australian eggs Benedict** - Hollandaise sauce mix
Spinach omelette with salmon	**Cheese and bacon eggy bread bake** - Mixed herbs, chives, parsley
Chilli cheese jalapeno omelette	**Avocado and egg quesadilla with salmon**
Quinoa scrambled eggs - Mixed herbs	**Cherry tomato and parmesan frittata** - Mixed herbs
Smoked salmon egg pots - Chives	**Soufflé omelette, quark cream and berries**

Appendix 5.3 – Set of recipes

Appendix 5.4 – Egg Food Frequency Questionnaire

24. Eggs

	Measure	Measures per day	Number of days per week
a) Boiled eggs (hot)	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
b) Hard boiled eggs (cold)	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
c) Fried eggs	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
d) Scrambled eggs	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
e) Poached eggs	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
f) Omelettes	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
g) Scotch eggs	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
h) Quiches/ savoury flans	1 slice	1 2 3 4 5+	R M 1 2 3 4 5 6 7
i) Egg sandwiches	1 sandwich	1 2 3 4 5+	R M 1 2 3 4 5 6 7
j) Egg salad	1 small bowl	1 2 3 4 5+	R M 1 2 3 4 5 6 7
k) Custards	1 small bowl	1 2 3 4 5+	R M 1 2 3 4 5 6 7
l) Meringues	1 nest	1 2 3 4 5+	R M 1 2 3 4 5 6 7
m) Sweet flan / Crème caramel	1 slice	1 2 3 4 5+	R M 1 2 3 4 5 6 7
n) Duck/Quail's eggs	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
o) Raw eggs	1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
p) I deliberately eat/use the yolk separate from the white	yolk of 1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
q) I deliberately eat/use the white separate from the yolk	egg white of 1 egg	1 2 3 4 5+	R M 1 2 3 4 5 6 7
r) Other	.....	1 2 3 4 5+	R M 1 2 3 4 5 6 7

Appendix 5.5 – Recipe feedback form

Habits and Lifestyles

Over the past 3 months, you have received a number of recipes from Bournemouth University as part of the Habits and Lifestyles study. These questions are about those recipes. We are interested to know whether you used them and what you thought of them.

1. **Did you use any of the recipes that were sent to you over the past 3 months?**
   - ○ YES, I have used one or more of the recipes
   - ○ NO, I have not used any of the recipes.

2. **Why did you decide to use or not use the recipes?**

   ……

   ……

3. **The recipes you have received are listed below. In the first column please tick the recipes you have used. Secondly, we would like to know if there are any reasons why you chose the recipes you used, and what you thought of them. For example, did you choose a recipe because it looked tasty, or easy to prepare, or because of the high protein content? And once you had tried it, what did you think? If there were some dishes you particularly liked, please put the letter 'F' for your 'favourite' recipes.**

Recipes used	Please mark your favourite recipes with the letter 'F'	Why did you choose this recipe? What did you think of it?
	Cheese and ham eggy bread	
	Spinach, feta and pine nut omelette	
	Egg cupcakes	
	Tuna and broccoli omelette	
	Fried egg naan with masala beans	
	Baked eggs with goat's cheese on ciabatta	
	Salmon scrambled eggs	
	Ham and egg cobbler	
	Croque madame	
	Mushroom and goat's cheese tortilla	
	Buck rarebit	
	Turkish eggs with Turkish toast	
	Moroccan spiced eggs and tomatoes with a minted yoghurt	
	Pizza omelette	
	Salmon and watercress frittata	
	Leftover roast chicken crustless mini quiches	
	Eggs Florentine	
	Chinese fried eggs	
	Turkish scrambled eggs	
	Smoked mackerel scramble	
	Special dippy eggs and soldiers	

Recipes used	Please mark your favourite recipes with the letter 'F'	Why did you choose this recipe? What did you think of it?
	Smoked salmon and asparagus omelette	
	Indian omelette	
	Pesto egg and ham Danish pastry	
	Huevos rancheros	
	Breakfast wrap	
	Spinach omelette with salmon	
	Chilli cheese and jalapeño omelette	
	Quinoa scrambled eggs	
	Smoked salmon egg pots	
	Masala scrambled eggs	
	Australian eggs Benedict	
	Cheese and bacon eggy bread bake	
	Avocado and egg quesadilla with salmon	
	Cherry tomato and parmesan frittata	
	Soufflé omelette, quark cream and berries	

4. **If you used the recipes, when did you mostly eat the dishes? (please tick all options that apply)**
    - Breakfast
    - Lunch
    - Evening meal
    - Another time of the day
    - At different times

5. **If you used the recipes, approximately how often did you eat the dishes?**
   - ○ Every day
   - ○ 3-4 times a week
   - ○ 1-2 times a week
   - ○ 1-2 times a fortnight
   - ○ 1-2 times a month

6. **Did you use any of the herb or spice packets that were sent to you?**
   - ○ YES, I used one or more of the herb or spice packets
   - ○ NO, I have not used any of the herb or spice packets

7. **Why did you decide to use or not use the herb or spice packets?**

   ……

   ……

8. **Is there anything we could change about the recipes to encourage you and other people to prepare the dishes?**

   ……

   ……

   ……

Thank you very much!

Please now return the questionnaire (no stamp needed) to:
FREEPOST – RTGG-USCA-GLHA,
BOURNEMOUTH UNIVERSITY,
Katherine Appleton,
Recipe Feedback,
Department of PSYCHOLOGY, POOLE HOUSE, TALBOT CAMPUS,
POOLE, DORSET, BH12 5BB.

Appendix 5.6 – Normality tests for baseline measures

Shapiro-Wilk tests were conducted to check whether the baseline measures had a normal distribution. The results are shown in table 5.6.1. Two variables shows to not be significantly different from a normal distribution are age (W (99) = .976, *p* = .066) and fat percentage (W (99) = .983, *p* = .228). All other variables were not normally distributed, or significantly different from a normal distribution.

Table 5.6.1 Shapiro-Wilk test of normality for all baseline measures.

	W	df	P value
Age in years	.976	99	.066
BMI in kg/m^2	.914	99	.000
Fat percentage of total body weight	.983	99	.228
Lean body mass in g	.957	99	.003
Handgrip strength in kg	.955	99	.002
SPPB score (0-12)	.944	99	.000
Egg intake per month	.902	99	.000
Protein intake per day in g	.957	99	.003
Protein intake in g/kg body weight	.943	99	.000
Energy intake in kcal	.958	99	.003
HR QoL score*	.903	99	.000
Physical activity in kcal/week**	.906	99	.000

*Health related quality of life was measured by the SF36 questionnaire.
**Physical activity was measured by the CHAMPS questionnaire.

Appendix 5.7 – Correlations baseline measures

Spearman correlations between the baseline measures are provided. Significant correlations are highlighted.

		BMI	Lean body mass	Handgrip strength	Leg extensions	SPPB score	HR QoL*	Physical activity	Egg intake	Protein intake	Energy intake
Age (y)	Correlation Coefficient	.067	-.114	-.119	-.073	**-.429**	**-.216**	-.010	.048	-.086	-.106
	Sig. (2-tailed)	.508	.259	.239	.472	**.000**	**.032**	.921	.638	.399	.297
BMI (kg/m2)	Correlation Coefficient		**.404**	.129	**.311**	-.148	**-.203**	.149	.078	.124	.100
	Sig. (2-tailed)		**.000**	.199	**.002**	.142	**.044**	.141	.440	.221	.326
Lean body mass (kg)	Correlation Coefficient			**.801**	**.258**	.047	-.014	**.273**	.002	.191	**.203**
	Sig. (2-tailed)			**.000**	**.010**	.639	.894	**.006**	.985	.059	**.043**
Handgrip strength (kg)	Correlation Coefficient				**.227**	.188	.078	**.236**	-.037	.147	.140
	Sig. (2-tailed)				**.024**	.061	.442	**.019**	.715	.146	.168
Leg extensions	Correlation Coefficient					.191	.163	.077	-.071	-.053	-.067
	Sig. (2-tailed)					.058	.108	.451	.490	.607	.510
SPPB score	Correlation Coefficient						**.453**	.101	.040	.101	.129
	Sig. (2-tailed)						**.000**	.319	.697	.318	.203
HR QoL*	Correlation Coefficient							.187	-.037	-.025	-.034
	Sig. (2-tailed)							.064	.717	.809	.737
Physical activity (kcal)	Correlation Coefficient								**.205**	.143	.085
	Sig. (2-tailed)								**.042**	.158	.405
Egg intake	Correlation Coefficient									**.355**	**.301**
	Sig. (2-tailed)									**.000**	**.002**
Protein intake (g)	Correlation Coefficient										**.947**
	Sig. (2-tailed)										**.000**

*Health Related Quality of Life measured with SF-36

Appendix 5.8 – Multiple Linear Regression of egg intake measured by SCG FFQ

Multiple linear regressions using the SCG FFQ egg intake data show egg intake at T2 can be significantly predicted by the model, $R = .829$, $R^2 = .687$, adjusted $R^2 = .656$, $F(9, 89) = 21.744$, and $p < .001$. Where higher egg intake at T2 is significantly predicted by higher egg intake at T1 (Beta = .700, $p < .001$), protein intake at T2 (Beta = .193, $p = .004$), and being a previous participant (Beta = .158, $p = .018$). Egg intake at T2 was not significantly predicted by the condition (Beta = -.037, $p = .536$). Results can be found in the table below

	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	-7.249	13.749		-.527	.599	-34.568	20.070					
Condition	-1.114	1.791	-.037	-.622	.536	-4.673	2.445	-.040	-.066	-.037	.971	1.030
Age	.105	.136	.050	.770	.443	-.165	.375	.088	.081	.046	.841	1.188
Gender	-.849	1.967	-.028	-.431	.667	-4.758	3.060	.039	-.046	-.026	.807	1.239
SCG FFQ Egg intake at T1	.806	.074	.700	10.864	.000	.658	.953	.779	.755	.644	.847	1.180
Protein intake at T2	.090	.030	.193	2.999	.004	.030	.150	.420	.303	.178	.852	1.174
BMI at T2	.163	.225	.045	.722	.472	-.285	.611	.191	.076	.043	.886	1.128
HR QoL at T2	-.010	.007	-.090	-1.393	.167	-.025	.004	-.203	-.146	-.083	.849	1.178
Physical activity at T2	.000	.000	.023	.358	.721	-.001	.001	.140	.038	.021	.818	1.222
Previous participation	7.220	2.982	.158	2.421	.018	1.295	13.145	.168	.249	.143	.827	1.210

The table below shows that SCG FFQ egg intake at T3 was also significantly predicted by the model, R = .817, R^2 = .667, adjusted R^2 = .633, $F(9, 89) = 19.820$, and $p < .001$. Higher egg intake at T3 was significantly predicted by being in the intervention group (Beta = -.161, p = .011), higher egg intake at T1 (Beta = .634, $p < .001$), higher protein intake at T3 (Beta = .276, $p < .001$), higher BMI at T3(Beta = .160, p = .016), lower physical activity at T3 (Beta = -.159, p = .022), and being a previous participant (Beta = .151, p = .024).

	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	-23.255	15.412		-1.509	.135	-53.879	7.369					
Condition	-5.385	2.072	-.161	-2.598	.011	-9.503	-1.267	-.159	-.266	-.159	.971	1.030
Age	.189	.157	.080	1.206	.231	-.123	.502	.150	.127	.074	.842	1.188
Gender	1.265	2.261	.038	.560	.577	-3.227	5.758	.088	.059	.034	.818	1.223
SCG FFQ Egg intake at T1	.819	.086	.634	9.472	.000	.647	.991	.711	.709	.579	.834	1.199
Protein intake at T3	.137	.032	.276	4.282	.000	.073	.201	.443	.413	.262	.903	1.108
BMI at T3	.596	.243	.160	2.455	.016	.114	1.078	.257	.252	.150	.879	1.138
HR QoL at T3	-.003	.008	-.024	-.365	.716	-.020	.014	-.145	-.039	-.022	.854	1.171
Physical activity at T3	-.001	.000	-.159	-2.322	.022	-.002	.000	.058	-.239	-.142	.797	1.255
Previous participation	7.727	3.373	.151	2.291	.024	1.025	14.429	.114	.236	.140	.865	1.157

Appendix 5.9 – Gender specific values for outcomes at each test session

Means and standard deviations for all measures per group per time point. All values are reported as Mean ± SD

	Intervention group T1 (n=53) (30F/23M)	Intervention group T2 (n=53)	Intervention group T3 (n=53)	Control group T1 (n=47) (24F/23M)	Control group T2 (n=47)	Control group T3 (n=47)
Egg intake per month	23 ± 17	28 ± 20	27 ± 22	21 ± 15	25 ± 20	22 ± 15
Female	22 ± 18	28 ± 22	27 ± 23	19 ± 12	21 ± 11	20 ± 12
Male	24 ± 16	27 ± 18	28 ± 20	23 ± 18	30 ± 25	24 ± 17
Protein intake in g per kg body weight	1.25 ± 0.43	1.21 ± 0.43	1.14 ± 0.48	1.27 ± 0.49	1.31 ± 0.49	1.26 ± 0.51
Female	1.34 ± 0.49	1.31 ± 0.51	1.19 ± 0.52	1.37 ± 0.48	1.38 ± 0.50	1.36 ± 0.50
Male	1.13 ± 0.31	1.09 ± 0.28	1.07 ± 0.43	1.16 ± 0.49	1.23 ± 0.49	1.15 ± 0.50
Protein intake per day in g	93 ± 30	90 ± 29	86 ± 36	91 ± 33	94 ± 35	90 ± 31
Female	91 ± 34	89 ± 34	82 ± 33	89 ± 32	90 ± 33	89 ± 31
Male	95 ± 26	92 ± 22	92 ± 39	93 ± 35	99 ± 36	92 ± 32
Protein energy percentage	17.02 ± 2.07	17.09 ± 2.63	16.94 ± 2.02	16.97 ± 2.12	17.65 ± 2.26	17.30 ± 2.35
Female	17.02 ± 2.28	17.30 ± 3.05	16.86 ± 2.25	17.29 ± 2.10	17.53 ± 2.19	17.78 ± 2.48
Male	17.01 ± 1.80	16.80 ± 1.95	17.05 ± 1.70	16.66 ± 2.13	17.76 ± 2.37	16.81 ± 2.15
BMI in kg/m^2 (Mean ± SD)	26.98 ± 4.18	27.10 ± 4.05	27.33 ± 4.45	26.26 ± 4.53	26.35 ± 4.31	26.50 ± 4.56
Female	26.78 ± 4.47	26.87 ± 4.27	27.21 ± 5.05	25.44 ± 4.54	25.46 ± 4.36	25.59 ± 4.44
Male	27.24 ± 3.85	27.40 ± 3.83	27.48 ± 3.63	27.12 ± 4.46	27.28 ± 4.15	27.44 ± 4.59
Fat percentage of total body weight	33.86 ± 8.78	34.53 ± 8.39	35.24 ± 8.80	32.27 ± 8.54	32.89 ± 8.32	33.37 ± 8.71
Female	39.99 ± 5.83	40.46 ± 5.58	41.26 ± 6.19	38.19 ± 6.26	38.79 ± 5.90	39.30 ± 6.06
Male	25.86 ± 4.40	27.06 ± 4.34	27.39 ± 4.34	26.09 ± 5.78	26.74 ± 5.54	27.18 ± 6.48
Fat mass in g	25.39 ± 7.58	26.04 ± 7.32	26.84 ± 8.05	23.89 ± 8.27	24.39 ± 7.92	25.02 ± 8.70
Female	27.83 ± 7.25	28.17 ± 6.93	29.23 ± 8.10	25.77 ± 7.94	26.25 ± 7.93	26.78 ± 8.29
Male	22.20 ± 6.93	23.36 ± 7.04	23.73 ± 7.00	21.92 ± 8.33	22.44 ± 7.60	23.19 ± 8.91
Lean percentage of total body weight	66.14 ± 8.78	65.47 ± 8.39	64.76 ± 8.80	67.73 ± 8.54	67.11 ± 8.32	66.63 ± 8.71
Female	60.01 ± 5.83	59.54 ± 5.58	58.74 ± 6.19	61.81 ± 6.26	61.21 ± 5.90	60.70 ± 6.06
Male	74.14 ± 4.40	72.93 ± 4.34	72.61 ± 4.34	73.91 ± 5.78	73.26 ± 5.54	72.82 ± 6.48
Lean body mass in g	50.36 ± 12.68	50.25 ± 12.63	49.99 ± 12.58	50.49 ± 12.81	50.21 ± 12.76	50.12 ± 12.72
Female	41.18 ± 5.90	41.02 ± 6.14	40.90 ± 6.10	40.74 ± 6.64	40.44 ± 6.08	40.25 ± 5.89
Male	62.34 ± 8.32	61.89 ± 8.23	61.84 ± 8.08	60.66 ± 9.24	60.42 ± 9.42	60.41 ± 9.21
Fat free mass index in kg/m^2 *	17.70 ± 2.74	17.51 ± 2.68	17.52 ± 2.64	17.67 ± 3.10	17.59 ± 3.09	17.52 ± 3.06
Female	15.88 ± 1.68	15.66 ± 1.60	15.75 ± 1.74	15.53 ± 1.87	15.39 ± 1.63	15.32 ± 1.55
Male	20.06 ± 1.91	19.85 ± 1.75	19.83 ± 1.64	19.90 ± 2.50	19.89 ± 2.53	19.82 ± 2.50
Fat mass index (FM/height^2) in kg/m^2	9.28 ± 3.40	9.41 ± 3.10	9.81 ± 3.73	8.59 ± 3.26	8.76 ± 3.12	8.98 ± 3.34
Female	10.89 ± 3.29	10.88 ± 2.87	11.46 ± 3.81	9.91 ± 3.21	10.07 ± 3.16	10.27 ± 3.25
Male	7.17 ± 2.20	7.54 ± 2.29	7.65 ± 2.27	7.22 ± 2.74	7.40 ± 2.46	7.63 ± 2.92

SPPB – 8ft walking speed in s	2.58 ± 0.75	2.49 ± 1.00	2.41 ± 0.82	2.35 ± 0.53	2.30 ± 0.49	2.23 ± 0.52
Female	2.62 ± 0.92	2.53 ± 1.28	2.49 ± 1.03	2.35 ± 0.59	2.28 ± 0.53	2.19 ± 0.58
Male	2.54 ± 0.47	2.45 ± 0.46	2.30 ± 0.44	2.34 ± 0.47	2.31 ± 0.45	2.27 ± 0.46
SPPB –Chair stand 5x time in s	16.94 ± 4.55	16.50 ± 4.50	15.13 ± 3.72	14.92 ± 3.97	15.69 ± 4.60	14.76 ± 3.51
Female	17.17 ± 4.88	16.94 ± 5.40	14.86 ± 4.15	14.56 ± 4.01	15.68 ± 5.68	14.35 ± 3.80
Male	16.68 ± 4.22	15.99 ± 3.19	15.45 ± 3.21	15.30 ± 3.99	15.71 ± 3.24	15.18 ± 3.21
Handgrip strength in kg	31.58 ± 10.51	32.37 ± 10.68	32.48 ± 9.93	33.78 ± 9.36	34.04 ± 9.65	33.60 ± 9.60
Female	24.98 ± 4.18	25.22 ± 3.87	25.79 ± 4.29	26.50 ± 4.32	26.63 ± 4.52	26.13 ± 4.75
Male	40.18 ± 10.07	41.70 ± 9.44	41.21 ± 8.25	41.37 ± 6.76	41.76 ± 7.17	41.40 ± 6.67
Total score SPPB	7.81 ± 2.34	8.38 ± 2.56	8.40 ± 2.41	9.32 ± 2.16	9.13 ± 2.09	8.81 ± 2.26
Female	7.70 ± 2.42	8.07 ± 2.89	8.27 ± 2.70	9.21 ± 2.47	9.17 ± 2.28	9.00 ± 2.60
Male	7.96 ± 2.27	8.78 ± 2.04	8.57 ± 2.02	9.43 ± 1.83	9.09 ± 1.93	8.61 ± 1.88
Fat intake in g	88 ± 35	86 ± 35	79 ± 36	83 ± 37	84 ± 35	82 ± 30
Female	87 ± 38	84 ± 42	75 ± 35	78 ± 28	81 ± 32	80 ± 28
Male	90 ± 32	88 ± 24	84 ± 36	87 ± 45	87 ± 37	84 ± 31
Carbohydrate intake in g	238 ± 74	228 ± 65	219 ± 78	246 ± 100	233 ± 88	234 ± 80
Female	229 ± 75	219 ± 64	206 ± 69	235 ± 94	219 ± 88	218 ± 66
Male	251 ± 72	241 ± 65	236 ± 88	256 ± 106	247 ± 87	249 ± 90
Energy intake in kcal	2195 ± 686	2132 ± 654	2021 ± 780	2179 ± 834	2142 ± 741	2099 ± 654
Female	2146 ± 721	2074 ± 726	1929 ± 709	2090 ± 748	2061 ± 720	2001 ± 596
Male	2262 ± 646	2208 ± 553	2140 ± 866	2267 ± 920	2224 ± 770	2196 ± 707
HR QoL score	681 ± 138	698 ± 134	696 ± 136	687 ± 123	703 ± 131	703 ± 131
Female	649 ± 156	666 ± 142	662 ± 145	675 ± 150	674 ± 163	675 ± 163
Male	724 ± 98	740 ± 112	741 ± 112	700 ± 90	731 ± 81	731 ± 81
Physical activity in kcal/week	4199 ± 3122	3424 ± 2605	3902 ± 2606	4455 ± 2976	3570 ± 2303	3727 ± 2417
Female	3608 ± 2557	2561 ± 1766	2981 ± 2100	3988 ± 3127	3327 ± 2413	3537 ± 2675
Male	4970 ± 3649	4550 ± 3096	5104 ± 2753	4923 ± 2807	3813 ± 2213	3917 ± 2173
Variation score ***	4.94 ± 2.97	4.77 ± 2.83	4.58 ± 2.73	5.02 ± 3.21	4.63 ± 2.13	4.59 ± 2.46
Female	4.97 ± 2.85	4.70 ± 2.67	4.30 ± 2.47	5.22 ± 3.18	5.00 ± 2.24	4.70 ± 2.27
Male	4.91 ± 3.19	4.87 ± 3.08	4.96 ± 3.05	4.83 ± 3.31	4.26 ± 2.00	4.48 ± 2.69
Egg eating occasions per month****	16.68 ± 11.77	17.74 ± 13.75	16.88 ± 13.39	17.39 ± 11.55	20.41 ± 11.89	18.57 ± 10.32
Female	15.00 ± 10.97	19.48 ± 15.83	18.53 ± 14.77	17.54 ± 11.01	19.63 ± 10.95	16.78 ± 8.91
Male	18.87 ± 12.65	15.36 ± 10.15	14.64 ± 11.18	17.24 ± 12.31	21.23 ± 13.00	20.43 ± 11.53

*Fat Free Mass Index (FFMI) by dividing the total fat free mass by height^2 (kg/m^2)

**Fat Mass Index (FMI) by dividing fat mass by height^2 (kg/m^2)

***Number of different egg preparations used per month (out of 19 options in the scale)

****Not including the amount of eggs eaten for each occasion

10. Glossary: List of abbreviations

Acronym	Meaning
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
CHAMPS	Community Healthy Activities Model Program for Seniors
CHD	Coronary Heart Disease
EAA	Essential Amino Acid
EAR	Estimated Average Requirement
FFQ	Food Frequency Questionnaire
FG	Focus Group
HR QoL	Health Related Quality of Life
I	Interview
IAAO	Indicator Amino Acid Oxidation
LRNI	Lower Reference Nutrient Intake
MPS	Muscle Protein Synthesis
NDNS	National Diet and Nutrition Survey
ONS	Oral Nutritional Supplements
PCA	Principal Component Analysis
RDA	Recommended dietary allowance
RNI	Reference Nutrient Intake
SCG-FFQ	Scottish Collaborative Group Food Frequency Questionnaire
SF-36	Short Form 36
SPPB	Short Physical Performance Battery
T1	Test session 1 (same for T2 and T3)