Nutrition knowledge of university students and the impact of a game-based e-programme on students' nutrition knowledge, diet quality and physical activity

Katerina Belogianni, RD, AFHEA, MSc

A thesis submitted for the degree of Doctor of Philosophy

Faculty of Health, Social Care and Education

Kingston University & St George's, University of London

April 2019

Declaration

I hereby declare that this thesis, submitted in partial fulfilment of my requirements for the degree of Doctor of Philosophy and entitled 'Nutrition knowledge of university students and the impact of a game-based e-programme on students' nutrition knowledge, diet quality and physical activity', represents my own work and has not been previously submitted to this or any other institution for any degree, diploma or qualification. In accordance with the Kingston University regulations, I also confirm that this thesis is the one upon which I expect to be examined for the above degree. This research was supported by a Kingston University Research Scholarship.

Katerina Belogianni

April 2019

Acknowledgements

I would like to express my thanks to Professor Ann Ooms for being a wonderful supervisor and taking the role of my first supervisor in the middle of my PhD. I would also like to thank my supervisors: Dr Dimitra Nikoletou and Dr Hannah Moir for their valuable guidance and continuous support throughout my PhD as well as Dr Hafez Ahmed for giving me the opportunity to undertake this PhD. I am deeply grateful to Dr Christine Baldwin for her expert guidance to undertake the systematic review of systematic reviews of this research as well as her constructive input throughout my PhD.

I appreciate the time and help provided by Professor Dimitris Makris, René Bach and the Kahoot! Team to develop and design the website and quiz-games, which were part of this research. I would like to thank the laboratory technicians Christopher Howe and Terry Turner for trusting me to use the laboratory facilities and equipment in order to conduct my research. I further acknowledge the help of Robert Grant and Anastasia Lykou for their statistical guidance and the Faculty members Ruth McIlmoyle and Sam Chidenga for facilitating all administrative procedures. I further acknowledge the significant contribution of KU Library and Learning Services for their immediate response to all requested articles.

I would like to express my sincere thanks to my husband, Paschalis Dellios to whom I dedicate this work, as well as my family and my mother (Eva) for believing in me and their encouragement to fulfil this PhD. I would like to thank my friends and concurrent PhD students Karishma Jivraj and Suchita Hathiramani for their emotional support during these four years. Finally, I would like to thank all those students who participated in my research as well as the KU alumni and friends who fundraised part of this research.

Publications and presentations arising from this thesis

Manuscripts in peer-reviewed journals

Belogianni K. and Baldwin C (2019). Types of interventions targeting dietary, physical activity and weight-related outcomes among university students: a systematic review of systematic reviews. *Advances in Nutrition* (ahead of publication).

Belogianni K., Ooms A., Hafez A., Nikoletou D., Grant R., Makris D., Moir H.J (2018). Rationale and Design of an Online Educational Program Using Game-Based Learning to Improve Nutrition and Physical Activity Outcomes Among University Students in the United Kingdom. *The Journal of the American College of Nutrition*, 2, pp. 1-8.

Conferences abstracts and other presentations

Belogianni K., Moir H.J., Nikoletou D., Hafez A., Ooms A (2017). Nutritional Knowledge, Diet Quality, Physical Activity and Weight-related outcomes among university students in UK: baseline characteristics of an online educational intervention. *European Federation of Association of Dietitians Conference.*

Belogianni K., Nikoletou D., Hafez A., Moir H.J., Ooms A (2017). Development of an internet-based educational programme targeting nutrition, physical activity and weight-related outcomes in university students. *Kingston University Postgraduate Research Week*.

Abstract

Studying at university is a challenging period with many students demonstrating unfavourable changes in their eating habits, physical activity behaviour and body composition. Universities should encourage health-promoting behaviours in students. The primary aim of this research was to identify dietary and physical activity interventions among university students, estimate their effectiveness, explore the nutrition knowledge of students and the impact of an intervention (e-programme) on students' nutrition knowledge, diet quality and physical activity.

First, a systematic review of systematic reviews was undertaken to identify and synthesise reviews targeting weight-related outcomes in university students globally. Eight reviews were identified, including 122 studies. The synthesis of findings demonstrated three main types of interventions: environmental, face-to-face and e-interventions. A moderate overall effect was found for environmental, face-to-face and e-interventions on dietary intake and a low effect for face-to-face and e-interventions on physical activity behaviour.

Second, a cross-sectional study was undertaken among UK-based university students (n=249) to explore nutrition knowledge, factors predicting a good level of knowledge and the relationship between knowledge and diet quality (n=86). The study demonstrated that students had an inadequate knowledge on fats, salt and weight-management methods. Studying a health-related course, being of White ethnic origin or perceiving health as very good to excellent, predicted a good level of knowledge. An

increase in knowledge of healthy food choices and diet-disease relationships was positively associated with diet quality.

And third, a randomised controlled trial (RCT) was undertaken to investigate the impact of an online programme using quiz-games (e-programme) on nutrition knowledge, diet quality and physical activity in UK-based university students (n=88). No significant differences on outcomes were found between the intervention and the control group at the end of the trial (10 weeks). The null findings remained when adherence to the e-programme was considered. Quizzes had a short-term effect on students' knowledge.

Finally, 11 students participated in a following evaluation study and reported that the e-programme was easy to follow and interesting but that it had minor impact on their knowledge.

This research provides new knowledge that could be used in designing more successful interventions within universities to address nutritional misconceptions and promote healthy changes in dietary and physical activity behaviour in students.

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Abbreviations

AMSTAR	A MeaSurement Tool to Assess systematic Reviews
ANOVA	Analysis Of Variance
BIA	Bioelectrical Impendace
BMI	Body Mass Index
CARDIA	Coronary Artery Risk Development in Young Adults
CI	Confidence Intervals
CVD	Cardiovascular Disease
FFQ	Food Frequency Questionnaire
FREC	Faculty Research Ethics Committee
FV	Fruit and Vegetables
GEE	Generalised Estimation Equations
GNKQ	General Nutrition Knowledge Questionnaire
GNKQ-R	General Nutrition Knowledge Questionnaire Revised
HDL	High Density Lipoprotein
HEI	Healthy Eating Index
HEIs	Higher Education Institutions
HPU	Health Promoting Universities
IPAQ	International Physical Activity Questionnaire
IPAQ-SF	International Physical Activity Questionnaire Shrot Form
ITT	Intention To Treat
KU	Kingston University
LDL	Low Density Lipoprotein

MCAR	Missing Completely At Random
MD	Mediterranean Diet
MEDLINE	Medical Literature Analysis and Retrieval System Online
MeSH	Medical Subject Heading
METs	Metabolic Equivalent Tasks
PAR-Q	Physical Activity Readiness Questionnaire
PI	Principal Investigator
PICOS	Population, Intervention, Comparison, Outcomes and Study Design
POP	Point Of Purchase
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
ROC	Receiver Operating Characteristic
SCOFF	Sick, Control, One stone, Fat, Food
SD	Standard Deviation
SE	Standard Error
SGUL	St George's, University of London
UK	United Kingdom
US	United States
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist to Hip Ratio

Chapter 1. Introduction to thesis

The transition from high school to university is a challenging period for students, particularly those moving away from home, as they become more independent and responsible for their life choices and behaviour. The context background of the current thesis presents the changes occurring in students' dietary and physical activity behaviour when moving to university and throughout the university years. The factors affecting these behaviours as well as their short-term and long-term adverse implications on students' health are also presented to address the importance of adopting and establishing healthy lifestyle habits at a young age.

Higher Education Institutions are settings that should contribute towards improving the health and well-being of its community by implementing health-promoting activities and programmes, which is part of the conceptual framework of the 'Healthy Universities', a holistic initiative introduced by the World Health Organization in 1998 and called to action in 2015 in Canada. In the UK, a network of Universities seems to follow the initiative (www.healthyuniversities.ac.uk). The research undertaken as part of this thesis is driven by this conceptual framework, based on the rationale that a healthy dietary and physical activity pattern can significantly contribute towards the overall health and well-being of students.

In research, many interventions have been implemented across the world to improve dietary, physical activity and weight-related outcomes in university students. In this thesis, these interventions were identified, and their findings were analysed to provide insights with regards to the different types of interventions and their overall effect to improve health outcomes in students. In the UK, only seven interventions were identified targeting dietary and physical activity behaviours in university students of which none used the world wide web to improve dietary behaviours. The use of web-based health-promoting approaches has increased in the last decades due to the advantages offered by the world wide web, which are presented in the thesis. Considering the potential of the world wide web to improve health and the paucity of evidence in the UK, research was conducted to explore the impact of an online programme, using game-learning, on dietary and physical activity knowledge and behaviour in university students.

Having good knowledge of the various nutrition topics (i.e. nutrition knowledge) seems an important determinant of dietary behaviour, as students with higher levels of knowledge seem to demonstrate better diet quality. The existing evidence with regards to levels of nutrition knowledge of UK-based students is limited and needs further investigation. Understanding the nutrition areas which students find difficult to comprehend may significantly contribute to designing more targeted and successful dietary interventions. Furthermore, it is important to investigate whether specific areas of nutrition knowledge contribute more towards a better diet quality in students and design interventions with relevant dietary information and advice. In the thesis, the knowledge of UK-based university students on various nutrition topics is explored as well as the relationship of nutrition knowledge with diet quality, in an attempt to address the aforementioned research topics.

The overall aim of the thesis was (1) to measure the overall effect of the existing types of interventions on weight-related behaviours in university students, (2) to provide new evidence on the level of nutrition knowledge and (3) the impact of an online game-based programme on students' nutrition knowledge, diet quality and physical activity.

For the purposes of the research, students from two London-based Universities across all faculties and academic disciplines were invited to participate, and their characteristics are described in detail in the thesis. In particular, the current thesis includes seven chapters, as described below:

Chapter 1 introduces the topic of the thesis and the conceptual framework of the research undertaken as part of this thesis. It also provides the outline of the thesis, including a brief description of the content of each chapter.

Chapter 2 provides the context background of the topic by illustrating definitions and terms used in the thesis, and the current literature demonstrating the lifestyle habits (diet, physical activity) of students and their impact on health, including factors affecting these behaviours. The concept of Health Promoting Universities, as well as the strengths and limitations of the world wide web to promote health in young people, is also reported. The aim and objectives of the research project are presented at the end of this Chapter.

Chapter 3 introduces the research methods and procedures applied to address the objectives. The rationale for the research designs and the data collection tools used to investigate the research hypotheses as well as the sampling methods and ethical considerations of the research are presented.

Chapter 4 presents a systematic review of systematic reviews (overview) undertaken in order to identify the different types of interventions targeting weight-related behaviours in students and estimate their overall effectiveness. In particular, the aim of the overview was to address the following research questions (objective 1 of the thesis):

- According to the existing literature, what are the main groups and subgroups of interventions based on their mode of delivery (face-to-face, online, environmental, etc.) targeting dietary, physical activity and weight-related outcomes in university students?
- Which of these groups or subgroups of intervention is more effective towards dietary, physical activity and weight-related outcomes among university students?

Chapter 5 presents the rationale, design and outcomes of a cross-sectional study undertaken in order to explore the level of students' knowledge on various nutrition topics, predictors of good knowledge and the potential relationship between knowledge and diet quality. For the purposes of this study 249 participants were recruited. In particular, the aim of the cross-sectional study was to address the following research questions (objective 2 of the thesis):

- What is the current level of nutrition knowledge in university students and what are the gaps in their knowledge?
- Which factors affect nutrition knowledge in university students?
- Which factors predict a good level of nutrition knowledge in university students?
- To what extend does nutrition knowledge positively associate with diet quality in university students?

Chapter 6 presents the rationale, design and implementation of a randomised controlled trial undertaken to investigate the impact of an e-programme using quiz-games on students' nutrition knowledge, diet quality and physical activity. Eighty-eight students participated in this study. In particular, the aim of the RCT was to address the following research questions (objective 3 of the thesis):

- To what extend does the e-programme significantly improve the level of nutrition knowledge in university students?
- To what extend does the e-programme significantly improve diet quality and physical activity in university students?
- To what extend does the level of adherence to the e-programme impact nutrition knowledge in university students?

After completion of the trial, an evaluation study was undertaken in a sub-sample of participants (n=11) to explore their perceptions about the value, feasibility and impact of the e-programme. The outcomes of the evaluation study are also presented and discussed in the chapter.

Chapter 7 summarises the key findings of the research and critically discusses the results of each study and the possible explanation of findings. Based on the key findings, recommendations for future research and the implications of this research in practice are discussed. The chapter concludes with the strengths and limitations of the research and future steps of the project.

The outline of the thesis, including the conceptual framework and chapter outputs, is shown in Figure 1.1

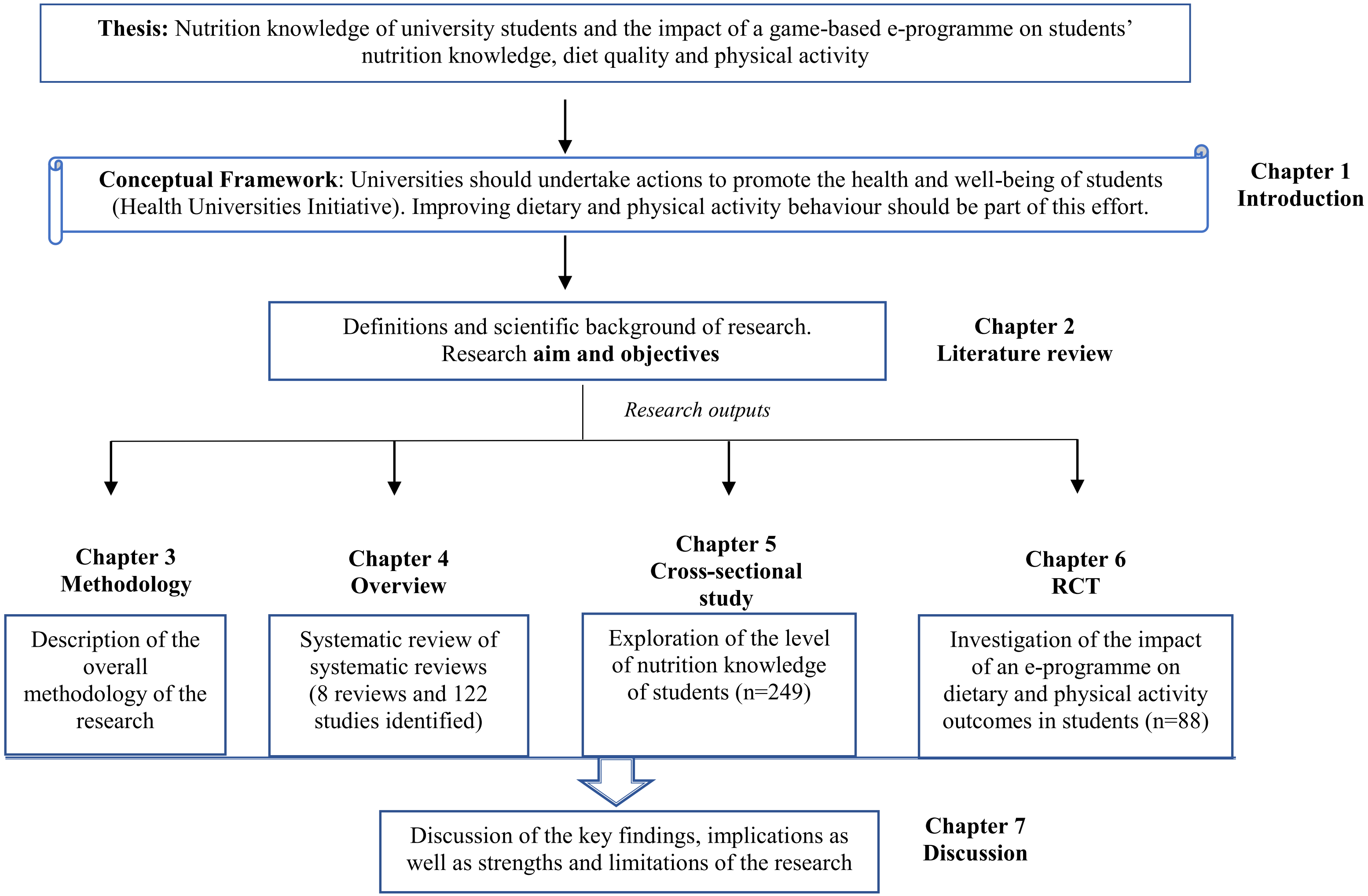


Figure 1. 1. Thesis outline and chapter outputs

Chapter 2. Literature Review

2.1 Overview of the chapter

The current chapter aims to provide the scientific background and review of existing literature in order to provide a greater insight in the prevalence of weight-related health behaviours (diet, physical activity) in university students and their implications on health. The prevalence of overweight and obesity and other metabolic risk factors in students is stated and the negative impact of having an excess weight in young age is presented through existing studies. The chapter also presents the existing evidence with regards to physical activity behaviour in students, determinants of physical activity and the implications of low levels of activity on health. Similarly, the chapter sets the background regarding the dietary habits of university students, their potential determinants and the short- and long-term impact of unhealthy dietary behaviours on students' health. Whether students acquire adequate levels of knowledge on various nutritional topics is also presented by reporting the results of cross-sectional studies conducted around the world. Also, the potential factors affecting nutrition knowledge and whether students with an increased knowledge demonstrate better dietary behaviour is presented based on the current literature. Finally, the chapter introduces the principles and framework of the Health Promoting University Initiative, which is a multi-component approach to improve the health and well-being of universities' communities and the potential of the world wide web as a source of information and means of delivering interventions to educate people and improve their health behaviour.

2.2 Transition to university: a challenging period

According to Lenz (2001), transitions are periods in life between two stable stages of human development associated with changes in individuals' skills to adjust and cope with the new experiences. Besides the personal characteristics and competence of individuals, environmental factors can also affect the transition from adolescence to young adulthood (Lenz, 2001). Environmental factors include the social network of family and friends as well as physical settings such as home, work or universities. Siri et al. (2016), stated that the university period is characterised by increases in independency, socialising, self-regulation and self-organisation and highlighted the need for preparatory courses. Three medical students from Manchester University in the UK responded by writing a letter to Siri et al. (2016) confirming that moving to university was indeed a difficult and challenging period in their lives with regards to financial planning, self-directed learning, workload management and living independency (Juma et al., 2016).

Deforche et al. (2015) followed 291 university students in Belgium from their final year of high school until the beginning of the second year at university and found that dietary and physical activity habits had changed during this transition. In particular, there was a moderate decrease in weekly intake of fruit and vegetables, food sources of fibre and dairy foods in contrast to an increased alcohol consumption, particularly in males (Deforche et al., 2015). The same study also found small decreases in weekly minutes spent on transportation and sports activity in both genders and a small but significant increase in time spent surfing the internet and studying. Decreases in time spent on sports and increases in internet surfing were related to the subsequent weight gain observed both in male and female students. In particular, males gained on average 4.2 kg and females 1.9 kg during the study period.

Gropper et al. (2012) measured changes in body composition parameters in students from their first to their last year at university. The study found significant increases in body weight (3.0 kg), body mass index (BMI) (1.0 kg/m^2) and body fat percentage (3.6%) as well as an increase in the prevalence of overweight (including obese) students from 18% to 31% over the 4-year period at university. A similar longitudinal study in the US assessed the dietary and physical activity habits of 732 students across seven semesters (Small et al., 2013). The study showed a 14% decrease in frequency of fruit and vegetable intake and a 6% decrease in frequency of undertaking physical activity across the semesters. These trends are similar to those found by Deforche et al. (2015) during the transition from high school to university, indicating that unfavourable changes in body weight and lifestyle behaviour do not stabilise after the first year at university but continue until the end of studies.

In the US, there is a great interest for the so-called phenomenon of *Freshmen fifteen*, which refers to the belief that students gain 15 pounds (6.8 kg) during their first year of studies (Brown, 2008). The actual weight gain seems to be much less as a recent meta-analysis including 22 longitudinal studies, demonstrated that students gained on average 1.36 kg (3lbs) (95% CI: 1.15-1.57) during their first year of studies (Vadeboncoeur et al., 2015). Another meta-analysis (n=49 studies) found that increases in mean body weight were significantly lower at the first year compared to the remaining years at university (1.52 kg vs 2.54 kg) (Fedewa et al., 2014). These findings indicate that there is not a specific time-frame when the majority of change-behaviour occurs, suggesting that health-promoting strategies should target students across all years at university. They also indicate the need to prevent the deterioration of healthy dietary and physical activity habits and promote the health of students during university years to facilitate a smooth transition process.

2.3 Weight-related parameters in university students

2.3.1 Definition and prevalence of overweight, obesity and metabolic risk

According to the World Health Organization (WHO), overweight and obesity is defined as abnormal or excessive fat accumulation that may impair health and is widely assessed with the BMI (kg/m^2) (World Health Organization, 2018). BMI is an easy, non-invasive and widely used index to establish the weight status of individuals. It is the result of the squared height (in metres) divided by the weight (in kilograms). Individuals with a BMI greater than or equal to 25 kg/m^2 are categorised as overweight while those with a BMI equal or greater than 30 kg/m^2 are categorised as obese. BMI is a rough estimate of body size but not of body fat mass or its' distribution. Therefore, BMI should be used with caution in people with an increased or low lean mass, fluid retention, children and adolescents as well as individuals from different ethnic groups (Centers for Disease Control and Prevention, 2011). Excess fat is distributed in various parts of the body, in particular the area around the abdomen (World Health Organization, 2008). Intra-abdominal fat is more likely to be related with health abnormalities rather than fat deposition in other parts of the body. Abdominal (or central) obesity is widely assessed by measuring waist circumference (WC) and waist-to-hip ratio (WHR) and, along with BMI, they are used to predict disease risk in adults such as cardiovascular risk, type 2 diabetes, types of cancer and overall mortality (Table 2.1) (World Health Organization, 2008).

Table 2. 1. Combined recommendations of BMI and waist circumference cut-off points made for overweight and obesity and association with disease risk

	Body mass index (kg/m^2)	**Obesity class**	**Disease risk (relative to normal weight and waist circumference)**	
			Men <102 cm Women < 88 cm	**Men>102 cm Women > 88 cm**
Underweight	<18.5			
Normal	18.5-24.9			
Overweight	25.0-29.9		Increased	High
Obesity	30.0-34.9	I	High	Very high
	35.0-39.9	II	Very high	Very high
Extreme obesity	>40.0	III	Extremely high	Extremely high

Source of table: World Health Organization (2008)

In the US, results from large cross-sectional studies including more than 1,700 students each, found that 33% and 28% of students were overweight, respectively (Burke et al., 2009; Odlaug al., 2015). These rates are very high compared to the ones reported in China among 1,228 university students, where the prevalence of overweight was 5.4% (Wu et al., 2012), implying that westernised dietary habits might contribute to increased BMIs in students. In the UK, The Health Survey for England in 2017 reported that between the age categories of 16-24, 25-34, 35-44 and 45-54 years, the prevalence of overweight (including obesity) was 37%, 57%, 65% and 72%, respectively, suggesting that adults start gaining weight at a young age which keeps increasing in later life (NHS Digital, 2018). Finally, the study by Nikolaou et al. (2015) among 1,275 university students in the UK, reported that 20% of students were overweight (including obese) at the end of the first academic year, although it should be noted that students provided self-reported measures.

Besides an increased BMI, other metabolic risk factors include an increased WC, elevated blood pressure, elevated low-density lipoprotein (LDL)-cholesterol, elevated fasting blood glucose, elevated triglycerides, elevated insulin resistance and low levels of high-density lipoprotein (HDL)-cholesterol (Harris, 2013). Metabolic syndrome is defined as the prevalence of a cluster of these aforementioned metabolic risk factors (Harris, 2013). Although the prevalence of metabolic syndrome appears very low in university students (<10%) (Arts et al., 2014), recent data from a cross-sectional study in the US showed that one-third of students had at least one metabolic risk factor, with the most prevalent being low HDL-cholesterol levels and increased WC (Yahia et al., 2016). This evidence is consistent with data from cross-sectional studies in Greece (Vergetaki. et al., 2011), South Africa (Smith, 2009) and Brazil (Freitas et al., 2013), which demonstrate that 43%, 38% and 30% of students respectively, had at least one metabolic risk indicator. Central adiposity, hypertension and low levels of HDL-cholesterol were commonly identified risk factors (Arts et al., 2014). It should be noted that, an increased BMI has been found to be positively associated with higher metabolic risk (Arts et al., 2014). Besides an increased metabolic risk, a high BMI is associated with short- and long-term implications on students' health, which are presented below.

2.3.2 Short-term and long-term implications of overweight and obesity on health

Increased body mass can negatively affect many aspects of students' health, mental and social performance. In particular, Odlaug et al. (2015) showed that overweight and obese students in the US had significantly lower academic performance, were more depressed and used more frequently dieting pills compared to their counterparts with a healthy weight. These findings are consistent with a study among medical students in Egypt, where excess body mass was associated with lower overall academic achievement, more symptoms of depression and higher anxiety and stress rates (Abdel Wahed & Hassan, 2016). Furthermore, overweight and obese students were susceptible to eating disorders (overeating and fasting practices) and guilty feelings and were highly concerned about their body weight or body shape, compared to students with a healthy BMI (Kass et al., 2017). A cross-sectional study among university students in Greece also found that obesity was significantly associated with the prevalence of cardiovascular risk factors such as hypertension, increased LDL-cholesterol, triglycerides and lower HDL-cholesterol while central adiposity was a predictor of abnormal lipid levels in students (Bertsias et al., 2003).

Despite the aforementioned implications, an increased body weight in early adulthood has been found to negatively impact health in later adulthood. In particular, a prospective observational study, which measured the BMI of university students in the UK aged 16-24 years in 1948-1968 and then again in 2000-2003, found that participants with a higher BMI in early adulthood had higher risk of mortality from cardiovascular diseases (Hazard Ratio per 5 kg/m^2 increase in BMI=1.15, 95% CI: 0.96-1.32) and mortality of cancers unrelated to smoking behaviour (Hazard Ratio=1.22, 95% CI: 1.03-1.45) (Carslake et al., 2016). In addition, the Coronary Artery Risk Development in Young Adults (CARDIA) Study, a large longitudinal study of 5,115 young people aged 18-30 years in the US, revealed that young adults with abnormal metabolic risk factors at baseline, such as high blood pressure, low HDL-cholesterol and high blood glucose, were two to three times more likely to develop cardiovascular abnormalities, such as coronary artery calcification (i.e. calcium phosphate in coronary arteries) over a 15-year period (Loria et al., 2007) while abdominal obesity was a potential predictor for atherosclerosis (i.e. hardening of the arteries) (Lee et al., 2007). Evidence from the CARDIA study also showed that weight gain was significantly related to adverse changes in cardiovascular risk factors (e.g. increases in LDL-cholesterol, blood pressure, fasting insulin) over a 10-year period, even in youths with a normal BMI at baseline (Norman et al., 2003).

2.3.3 Socio-demographic and behavioural factors associated with an increased body weight

Low physical activity levels and having a disturbed relationship with food has been found to be positively related with an increased body weight. In particular, the study by Desai et al. (2008) among 4,201 undergraduates in the US showed that students who were physically inactive were 1.4 times more likely (Odds Ratio=1.4, 95% CI: 1.2-1.6) of being overweight while those treated in the past for an eating disorder were 1.7 times more likely (Odds Ratio= 1.7, 95% CI: 1.2-2.5) of being overweight. Also, mean BMI was positively associated with the year at university. It should be noted that body weight and height measures were self-reported which might have biased the validity of outcomes while dietary habits were not assessed in the study. A similar cross-sectional study was undertaken among 6,773 university students across 22 countries in Latin America, Africa and Southeast Asia (Peltzer et al., 2014). The study explored the relationship between demographic, social, dietary, physical activity and mental health factors and BMI status while anthropometry was assessed by researchers. In both male and female participants, living in a higher income country, having poor mental health (e.g. depression) and trying to avoid fats were positively associated with overweight and obesity. In males, physical inactivity and smoking were additional positive correlates of an increased BMI. Age also affected body weight, as being younger in men and older in women was associated with overweight and obesity in this study. However, due to the mixed population of participants from low-, middle-, and high-income countries, inferences to broad student populations should be drawn with caution while no similar studies conducted in Europe were identified.

2.4 Physical activity in university students

2.4.1 Physical activity behaviour

According to the guidelines of the UK Department of Health, the recommended levels of physical activity for adults are at least 150 minutes of moderate activity or 75 minutes of vigorous activity per week, in addition to strengthening exercises two or more days a week (Department of Health, 2011). With regards to walking activity, there is evidence recommending that 10,000 steps per day correspond to an active level of physical activity (Tudor-Locke et al., 2008). The study by Arias-Palencia et al. (2015) provided accelerometers to 296 Spanish students for seven consecutive days to assess their levels of physical activity. Students were more active on weekdays compared to weekends. The study also found that 30% of students reached the level of 30 minutes per day of moderate activity at least 5 days per week. The same study also reported that only 5.4% of participants undertook at least 150 minutes per week of moderate activity or 75 minutes per week of vigorous activity (in bouts ≥10 minutes) and 28.1% reached the targeted number of 10,000 daily steps. These findings are similar to the ones found by a cross-sectional study with 906 Czech students, which used pedometers to assess walking activity and reported that only 9% of the students met the criterion of 10,000 steps per day (Sigmundová, et al., 2013). The fact that Spain has more sunshine periods in comparison to the Czech Republic, which also on average has lower temperatures most months of the academic year, might explain the different walking rates found in these two studies which, otherwise, used similar methods to assess daily steps.

In the US, a similar study used the International Physical Activity Questionnaire (IPAQ) to assess the levels of physical activity in 348 university students (Kang et al., 2014). Based on the category criteria of the questionnaire, 13.2% of students had a low level, 28.8% had a moderate level and 57.9% had a high level of physical activity. Another study in Michigan (US) which used a similar questionnaire to assess physical activity found that 32.6% of students reported doing exercise more than 4 hours per week (Yahia et al., 2016). In the UK, a large epidemiological study in 3,706 undergraduate students assessed the level of physical activity by asking students to report the number of days in the past week they performed vigorous exercise for at least 20 minutes, moderate exercise for at least 30 minutes and strengthening exercises (El Ansari et al., 2011). The study reported that 34.5% of students participated in vigorous activity three or more times, 14.9% of students participated in moderate activity five or more times and 32.1% of students did exercises to strengthen their muscles at least two times in the past week. Males outperformed females significantly in terms of amounts of exercise in all types and levels of physical activity (El Ansari et al., 2011). The use of self-reported measures of physical activity in these studies could explain the higher prevalence of active students identified compared to the ones found by Arias-Palencia et al. (2015), which used objective methods (accelerometers) to assess activity levels.

Adopting and maintaining a high level of physical activity is beneficial for students' health as described in the following paragraphs.

2.4.2 Physical activity behaviour and implications on health

The long-term benefits of engaging in regular physical activity include the reduced risks of obesity, coronary heart disease, type 2 diabetes and mental health conditions in adults as shown in a meta-analysis of 15 longitudinal studies (Reiner et al., 2013). In young adults, the CARDIA study demonstrated that participants with low physical activity levels had an increased metabolic risk (abnormal blood pressure, glucose levels, WC, triglycerides and HDL-cholesterol) at baseline (aged 18-30 years) compared to those with higher physical activity levels while this trend remained over the 20-year period of follow-up (Camhi et al., 2013). The CARDIA study also found that physical activity levels were inversely associated with body weight over time (Schmitz et al., 2000) while the incidence of hypertension after 15 years was significantly lower in active compared to inactive individuals (Hazard Ratio= 0.83, 95% CI: 0.73, 0.93) (Parker et al., 2007). The same study measured cardiorespiratory fitness levels using a symptom-limited exercise test on a treadmill and reported that those with high baseline fitness levels had 40% lower chances (Hazard Ratio=0.59, 95% CI: 0.36, 0.97) to develop coronary artery calcification (i.e. calcium phosphate in coronary arteries) 15 years later (Lee et al., 2009).

Another longitudinal study investigating physical activity patterns of 1,869 Norwegian students aged 13-19 years over a 10-year period, found that those who were initially active and maintained active throughout, had significantly lower WC, BMI, resting heart rate and diastolic blood pressure as well as elevated levels of HDL-cholesterol compared to those who were inactive and to those that were inactive at the beginning or increased their activity later (referred to as the adopters) (Rangul et al., 2012). In addition, active students recorded better mental health. When comparing the inactive students to the adopters, resting heart rate improved over time in both genders and total cholesterol levels only in females (Rangul et al., 2012). The findings of these longitudinal studies suggest that students should be active in adolescence and remain active throughout young adulthood to maintain a good health and reduce their disease risk in later life.

2.4.3 Determinants of physical activity behaviour

Physical activity behaviour is affected by many factors. The study by Scarapicchia et al. (2015) showed that male students were more likely to meet the recommended levels of moderate-to-vigorous physical activity and completed strengthening exercises at least twice per week compared to females (Odds Ratio=2.48, 95% CI: 1.82-3.3) as well as Caucasian students (versus not Caucasian) (Odds Ratio=2.34, 95% CI: 1.64-3.24) and those trying to lose weight (versus not trying) (Odds Ratio=1.55, 95% CI: 1.14-2.12). Similar studies in the US (Yahia et al., 2016) and the UK (El Ansari et al., 2011) found that male students engaged in greater amounts of exercise compared to females. Diet and smoking were determinants of physical activity in a study among 2,051 Spanish students, where those consuming the recommended fruit and vegetables portions (≥5 a day) and not smoking were more likely to meet the physical activity guidelines (Romaguera et al., 2011). Spending time in front of the computer or television was negatively related with physical activity behaviour while students with a university-educated or physically active mother had higher odds to meet physical activity guidelines (Romaguera et al., 2011). Findings from a large-cross sectional study in students across 23 low-, middle- and high-income countries in Latin America, Africa and Southeast Asia demonstrated that older age, skipping breakfast and lower perceived social support were positively associated with lower levels of physical activity (Pengpid et al., 2015).

Finally, Deliens et al. (2015a) conducted seven focus groups to explore perceived determinants of physical activity behaviour among university students in Belgium. Students perceived a cluster of personal, social and environmental factors to affect their physical activity behaviour. Individual factors included the perceived joy of doing exercise, time, convenience and self-discipline. Social factors included the influence of peers, friends, family and social connections. Environmental factors included availability and accessibility of sports centers/gyms, weather conditions and membership fees in addition to the macro-environment including the influence of media and advertising. University life characteristics, such as living on/off campus and exam or other stressful periods, were also reported by students as factors affecting their physical activity behaviour.

2.5 Dietary behaviour in university students

2.5.1 Energy, macronutrient and micronutrient intakes

Total energy intake is the amount of energy (kcal) consumed by individuals daily (Scientific Advisory Committee on Nutrition, 2011). Macronutrients include carbohydrates, protein and fat, while micronutrients include vitamins and minerals (Department of Health, 1991). Only macronutrients and alcohol provide energy in the body while micronutrients are caloric-free (Department of Health, 1991). To maintain optimal health and reduce disease risk, various organisations and countries have established daily recommended intakes (Dietary Reference Intakes, Guideline Daily Amount, etc.) to meet the nutrient requirements of individuals (Department of Health, 1991). Findings from cross-sectional studies in Europe (Greece, Spain) (Chourdakis et al., 2011; García-Meseguer et al., 2014) and the US (Burke et al., 2009) reported that male students consumed on average more calories than female students while both genders consumed higher amounts of fats than recommended (Table 2.2). An excess intake of fat, particularly saturated fat, can raise LDL-cholesterol which is a risk factor for cardiovascular diseases (CVD) (Sacks et al., 2017). Intakes of saturated fat exceeded the recommended levels in a study undertaken by Chourdakis et al. (2011), ranging from 10% to 15% of total energy intake while the recommended limit is less than 10% (data not shown in the table).

Chourdakis et al. (2011) also found low intakes of folate in students. Decreased plasma folate, followed by low homocysteine concentrations, is a biomarker of chronic diseases such as CVD and cancer, while in women, adequate folate levels are crucial during reproductive and early pregnancy periods to prevent neural tube defects of the fetus (Bailey et al., 2015). Excess intakes of sodium (salt) were found among US students (Burke et al., 2009). A low sodium intake has been associated with optimal blood pressure both in adults and children (Aburto et al., 2013). Other studies among university students have also shown inadequate intakes of vitamin D and vitamin E (Correa-Rodríguez et al., 2018). The above intakes were assessed using self-reported 3-day food records in the studies undertaken by Burke et al. (2009) and Chourdakis et al. (2011) and two non-consecutive 24-hour recalls interviewed by researchers in the study by García-Meseguer et al. (2014). Both methods are commonly used in epidemiology to assess dietary intake and each has strengths and limitations which are further discussed in Chapter 3. These methods are less accurate compared to objective methods (e.g.

direct observation, biomarkers), however, when participants or the interviewer are trained, issues such as underreporting of dietary intake, are reduced (Shim & Kim, 2014).

Table 2. 2. Estimating means of energy and nutrient intakes according to cross-sectional studies in university students[1]

Study	Country	Partici-pants	Gender	Total energy intake	Macro-nutrients	Micronutrients	
						Vitamins	**Minerals**
				Mean kcal ± SD	Mean % of total energy intake	Mean daily intake	Mean daily intake
Burke (2009)	US	1,701 students	Males	2,740 ± 842	CHO: 50 (45-65) PRO: 17 (10-35) FAT: 31 (10-35)	Vit A (μg RAE): 2,666 (900) Vit D (μg): 5.7 (5.0) Folate (μg): 434 (400) Vit C (mg): 173 (90)	Calcium (mg): 1,206 (1,000) Potassium (mg): 3,345 (4,700) Iron (mg): 20 (8) **Sodium (mg): 4,335** (≤2,300)
			Females	1,879 ± 547	CHO: 54 (45-65) PRO: 16 (10-35) FAT: 35 (10-35)	Vit A (μg RAE): 2,399 (700) Vit. D (μg): 3.7 (5.0) Folate (μg): 383 (400) Vit C (mg): 129 (75)	Calcium (mg): 904 (1,000) Potassium (mg): 2,249 (4,700) **Iron (mg): 15.2** (18) **Sodium (mg): 3,004** (≤2,300)
García-Meseguer (2014)	Spain	284 students	Males	2,117 ± 552	CHO: 41 (54) PRO: 17 (9) **FAT: 39** (<32)		
			Females	1,861 ± 459	CHO: 41 (54) PRO: 16 (9) **FAT: 41** (<32)		

Study	Country	Partici-pants	Gender	Total energy intake	Macro-nutrients	Micronutrients	
						Vitamins	**Minerals**
				Mean kcal ± SD	Mean % of total energy intake	Mean daily intake	Mean daily intake
Chourdakis (2011)	Greece	215 students	Males	1766 ± 827	CHO: 42 PRO: 18 **FAT:37** (<30)	Folate (µg): **196** (400)	Sodium (mg): 2,208 (<3,000)
			Females	1517 ± 636	CHO: 45 PRO:16 FAT: 37 (<30)	Folate (µg): **219** (400)	Sodium (mg): 1,854 (<3,000)

[1]In brackets are recommended intakes per age and gender as presented in the studies. Bold indicate abnormal (excess or lower) intakes than the recommended.

2.5.2 Dietary and drinking habits

Nutrient intakes reflect the dietary habits of students. A cross-sectional study among 2,812 Canadian students found that only 10% of participants reached the targeted daily intake of five or more portions of fruit and vegetables (FV), where FV intake was assessed by asking students to record their usual intake (portions per day) (Scarapicchia et al., 2015). Another study across seven universities in the UK assessed FV intake as well as intake of sweets and confectionary by using a self-reported questionnaire, where students reported the frequency of their usual consumption (El Ansari et al., 2011). This study found that only 15% of participants consumed at least five portions of FV per day and only 32% consumed sweets less than once per week. A similar study conducted at Michigan University (US) assessed food frequency consumption of students by using a questionnaire to inquire, among others, about the intake of FV, sweets, processed meat (e.g. salami, sausages), fast-food and pizza (Yahia et al., 2016). The study reported that only 8% of males and 9% of females were eating more than two portions of FV per day while 26% of males and 6% of females were eating processed meat twice daily. Regarding energy-dense foods, the study reported 38% of males and 30% of females eating sweets and cakes once to two times per week, 35% of males and 28% of females eating fast-food once to two times per week while 35% of males and 41% of females eating at a pizzeria every day (Yahia et al., 2016). These studies provide an estimate of students' habitual dietary habits, however, potential recall bias should be considered when students record their intakes (Shim & Kim, 2014).

Drinking behaviour, and in particular the consumption of sugary drinks, are an important part of diet as they contribute towards individuals' total sugar and energy intake (Martinez et al., 2016). The study by Deliens et al. (2015b) among Belgian students found that mean consumption of soft drinks was 424 ± 445 (ml/day) of which 52% derived from sugar-sweetened carbonated beverages, 26% from fruit juices, 18% from diet soft drinks and 9% from energy and sports drinks. Another study in a southwest university in the US found that 17.5% of students had consumed energy drinks in the past week while energy drink consumption was positively associated with the intake of sodas and frozen meals (Poulos & Pasch, 2015). A study among Caribbean students showed that 74% of the participants were drinking up to five energy drinks per month with males being higher consumers than females (Reid et al., 2015). On average, a sugary drink contains 7-10 teaspoons of sugar. Energy drinks also contain caffeine (83-215 mg per can), which in high amounts, can cause elevated heart rate, headaches, increased urination and insomnia (Reid et al., 2015).

As individuals tend to consume a cluster of foods and drinks (providing sometimes the same nutrients) and, considering the synergistic effect of foods on health, researchers developed dietary patterns based on the intake of food combinations (Tucker, 2010). The dietary patterns followed by students and their implications on students' health are described in the following paragraphs.

2.5.3 Dietary patterns

Indexes or scores, such as the Healthy Eating Index (HEI) (Kennedy et al., 1995) and the Mediterranean Diet (MD) Score (Trichopoulou et al., 2003), have been used to assess a cluster of dietary habits in order to provide an estimate of overall diet quality in various populations. García-Meseguer et al. (2014) assessed the diet quality of 284 Spanish students by using the HEI and the MD tools. Based on the HEI tool, only 3.9% of participants reached a greater than 80 overall score, which indicated a good diet quality, while based on the MD tool, 5.3% of students reached a score greater than 6, indicating high adherence to the MD pattern. The same study also reported that lunch was the largest meal of students by providing 36% of their daily energy intake, followed by dinner (27%), snacking (21%) and breakfast (16%), implying that students tend to consume small breakfast meals or skip breakfast altogether (García-Meseguer et al., 2014). This is also evident in the systematic review by Pendergast et al. (2016), which found that breakfast was the most missed meal, skipped by 14% to 89% of the participants. A recent published large cross-sectional study by Sprake et al. (2018) investigated the dietary habits using a self-reported food frequency questionnaire (FFQ) in university students from five UK universities across England. The following four main dietary patterns were identified, based on 1,448 student responses: 'vegetarian', 'snacking', 'health-conscious' and 'convenience, red meat and alcohol'. The 'vegetarian' and 'health-conscious' were nutrient-dense patterns characterised by high intakes of pulses, fruits, vegetables and oily fish in contrary to the other two poor-nutrient patterns, which were characterised by energy-dense snacks (e.g. biscuits, pastries, sweets) and high intakes of fast-food and processed meat. The 'convenience, red meat and alcohol' pattern was identified most consistently across universities and it was associated with other unhealthy lifestyle habits such as eating take-away meals, smoking and physical inactivity (Sprake et al., 2018). Adherence to healthy or unhealthy dietary patterns can significantly impact students' health as described in the following paragraphs.

2.5.4 Dietary behaviour (habits, patterns) and implications on health

Similar to physical activity behaviour, the longitudinal CARDIA study explored the relationship between dietary habits of young adults and health risk in later adulthood (Duffey et al., 2012). The researchers investigated following a 'prudent' dietary pattern (characterised by high intakes of fruit, whole grains, milk, nuts, seeds) or a 'western' dietary pattern (characterised by high intakes of fast-food, meat, pizza, snacks) and the incidence of cardiometabolic risk over a 20-year period (Duffey et al., 2012). Those following a 'prudent' diet compared to a 'western' diet had significantly lower levels of LDL-cholesterol (Hazard Ratio=0.87, 95% CI: 0.75-0.99), triglycerides (Hazard Ratio=0.78, 95% CI: 0.67-0.92), hypertension (Hazard Ratio=0.84, 95% CI: 0.73-0.98) and metabolic syndrome (Hazard Ratio=0.77, 95% CI: 0.66-0.91). Another cohort study among 19,138 Spanish university students (the SUN cohort), calculated a healthy eating score (0-10 points) at baseline, characterised by high intakes of fruit, vegetables, fish, fibre and low intakes of meat, sweets, and pastries, in order to investigate the incidence of cardiovascular disease at follow-up (approximately 9 years later) (Santiago et al., 2016). The study found that a higher healthy eating score was associated with significantly lower risk of developing CVD [for a score of 9-10 points, Hazard Ratio= 0.31, 95% CI: 0.15-0.67)] compared to the lowest score (0-2 points).

Regarding breakfast consumption, the CARDIA study suggests that eating breakfast daily versus occasionally protects against the development of abdominal adiposity (Hazard Ratio=0.78, 95% CI: 0.66-0.91), obesity (Hazard Ratio: 0.80, 95% CI: 0.67-0.96), hypertension (Hazard Ratio=0.84, 95% CI: 0.72-0.99) and metabolic syndrome (Hazard Ratio= 0.82, 95% CI: 0.69-0.98) over an 18-year period (Odegaard et al., 2013). This might be explained by the fact that the time and content of breakfast meals seem to positively affect blood glucose, insulin and lipid metabolism profiles (Leroith, 2012).

With regards to beverage intake, the SUN cohort study among 8,157 Spanish graduates, found that frequent consumers (highest versus lowest quartiles) of sugar-sweetened beverages had twice the likelihood of developing metabolic syndrome (Odds Ratio=2.2, 95% CI: 1.4-3.5) and central obesity (Odds Ratio=2.3, 95% CI: 1.9-2.7) and were 60-70% more likely to develop high blood pressure (Odds Ratio=1.6, 95% CI: 1.3-2.1), triglyceride levels (Odds Ratio=1.7, 95% CI: 1.1-2.6) and impaired fasting glucose (Odds Ratio=1.6, 95% CI: 1.1, 2.2) over a 6-year follow-up period (Barrio-Lopez et al., 2013). Similar results were found in a meta-analysis, where high consumption of sugary drinks was positively associated with an increased risk of obesity, metabolic syndrome, type 2 diabetes and cardiometabolic disorders (Malik et al., 2010).

2.5.5 Determinants of dietary behaviour

Determinants of students' food choices include their personal characteristics and beliefs, their social life and environment, the university environment, the local food settings, the living arrangement and their exposure to advertising. Individual traits such as taste, self-control, time management, meal preparation skills, convenience, religious beliefs and previous eating habits can all positively or negatively affect eating habits

(Deshpande et al., 2009; Boek et al., 2012; Deliens et al., 2014). Limited access to healthy food and high food prices constitute additional reasons for unhealthy food choices (Deliens et al., 2014). Family, friends, partners and peers play a significant role, as young people tend to consume more fast-food and sugar-sweetened beverages if their family and friends do so (Pelletier et al., 2014). This might be due to role modelling as studies found associations between parents' and adolescents' dietary intakes (Hanson et al., 2005).

Living arrangements might also impact students' food choices. Data from a cross-sectional study among 2,402 first-year students from Germany, Denmark, Poland and Bulgaria revealed that those living away from their parents consumed less fruit, vegetables and meat (El Ansari et al., 2012). The authors of the study speculated that financial limitations (e.g. cost of meat), lack of parental control and time needed to prepare meals (e.g. cook vegetables) might explain these findings. However, another study found that living away from home was positively correlated with meal preparation skills, without affecting dietary habits of students (Pelletier et al., 2014). On the other hand, residents in student accommodation halls seem to be frequent buyers of savoury snacks, desserts and sugary beverages (Nelson & Story, 2009) while those who purchase frequently food and beverages from the campus area seem to skip breakfast and consume high amounts of fat and added sugars (Pelletier & Laska, 2013). This might be explained by the high number of vending machines and the quality of food served in university residencies. Food advertisement exposure was also related with increased consumption of unhealthy and energy dense snacks in a study including university students (Zimmerman & Shimoga, 2014). Finally, data from student focus groups reported that perceived stress affects students' eating habits towards healthier or unhealthier choices (Deliens et al., 2014).

Knowledge of nutrition has been associated with improved dietary behaviour but the role of knowledge as a determinant of dietary behaviour needs further investigation, considering that many of the aforementioned factors affecting dietary intake are non-modifiable or difficult to change (e.g. family, academic-related stress). The impact of knowledge on students' dietary behaviour as well as the level of their knowledge on various nutrition topics according to the current literature are presented in the following paragraphs.

2.6 Nutrition knowledge in university students

2.6.1 Nutrition knowledge and dietary behaviour

Knowledge can positively impact eating behaviour. In particular, the systematic review by Spronk et al. (2014) investigated the relationship between nutrition knowledge and dietary intake in mixed adult populations (community and athletic). The review identified 29 studies and demonstrated a positive, although weak, association between increased knowledge and improved dietary intake. It should be noted that a high heterogeneity was found in studies regarding the assessment methods of knowledge and dietary intake which reduces the validity of inferences. With respect to university populations, Kolodinsky et al. (2007) assessed the relationship between knowledge and adherence to the dietary guidelines in students in the US. The study found that for specific food groups (fruit, dairy, protein and wholegrains) an increased knowledge was related with better food choices. A similar cross-sectional study among 1,005 students in Croatia reported that participants with higher adherence to dietary guidelines demonstrated significantly higher levels of nutrition knowledge. Also, knowledge was positively correlated with the intakes of fruits, vegetables, grains, dairies and meat (correlation coefficients ranged from 0.19 to 0.21, $p<0.01$) and negatively correlated with intakes of extras (such as solid fats, sugars, alcohol), oils and total energy (correlation coefficients ranged from -0.20 to -0.31, $p<0.01$) (Kresić et al., 2009).

Nutrition knowledge seems also to indirectly impact eating habits (Wardle et al., 2000). The study by Cooke & Papadaki (2014) among 500 university students across 37 UK Universities found that nutrition knowledge was significantly correlated (correlation coefficient 0.20, $p=0.01$) and was a predictor of food labelling use (Odds Ratio= 1.03, 95% CI: 1.01-1.04, $p<0.001$). The same study also found that nutrition knowledge was positively associated with diet quality, with or without considering use of food labels. Similar results were found in Misra (2007) (US), which reported that nutrition knowledge, when accompanied by positive attitudes towards usefulness, accuracy and truthfulness of food labels, was a strong predictor of food label use in students. These findings indicate the importance of incorporating nutrition knowledge as an outcome in health promoting strategies and implement interventions to increase the level of knowledge in students. The following paragraphs aim to illustrate data from existing cross-sectional studies across the world which assessed the knowledge of various nutritional aspects among university students.

2.6.2 Nutrition knowledge in university students

Nutrition knowledge by university students have been investigated worldwide with eight studies conducted in the United States, five in Canada, Asia and Africa (each), three in Europe and only one in England (Table 2.3). The number of participants in the studies ranged from 129 (Bottcher et al., 2017) to 6,638 (Matthews et al., 2016). Some studies included students across different academic disciplines (Boland et al., 2015) while others focused on students from a specific field of study such as pharmacy and dietetics (Morawska et al., 2016).

Table 2. 3. Cross-sectional studies assessing nutrition knowledge in university students

Aspects of Nutrition Knowledge	Study (country)	Mean score (%) of correct answers
Food groups (recommendations, portion sizes)		
Dietary recommendations	Peltzer 2002 (S. Africa)	50.5
	Kolodinsky 2007 (U.S.)	60.0
	Nabhani-Zeidan 2011 (Lebanon)	~66.4
	Cooke 2014 (UK)	72.7
Fruits and vegetables	Matthews 2016 (Canada)	27-39[a]
Milk/alternatives	Matthews 2016 (Canada)	11-22[a]
Fermented dairy products	Mazier 2007 (Canada)	17.5
Whole-grain products	Williams 2013 (Canada)	53.8
Healthful food choices	Peltzer 2002 (S. Africa)	47.2
Number of food groups	El-Sabban 2011 (Kuwait)	77.4
Nutrients		
Carbohydrates	Al-Isa 2014 (Kuwait)	61.2
Fibre	Al-Isa 2014 (Kuwait)	49.7
Protein	Al-Isa 2014 (Kuwait)	47.8
	El-Sabban 2011 (Kuwait)	72.0
Fat/lipids	Al-Isa 2014 (Kuwait)	~50.0
	Jasti 2010 (U.S.)	57.8
	Mazier 2007 (Canada)	63.1
	El-Sabban 2011 (Kuwait)	69.0
Vitamin D	Boland 2015 (Canada)	29.4
	Zhou 2016 (China)	**42.6**[b]
Sources/function of nutrients	Peltzer 2002 (S. Africa)	49.8
	Al-Isa 2014 (Kuwait)	57.0
	Cooke 2014 (UK)	68.1
	El-Sabban 2011 (Kuwait)	69.4
	Nabhani-Zeidan 2011 (Lebanon)	~73.5
Sodium	Al-Isa 2014 (Kuwait)	61.4
Water	El-Sabban 2011 (Kuwait)	69.0
Diet and disease relationship		
Chronic diseases	Peltzer 2002 (S. Africa)	42.7
	Cooke 2014 (UK)	45.0
	Nabhani-Zeidan 2011 (Lebanon)	13-56

Aspects of Nutrition Knowledge	Study (country)	Mean score (%) of correct answers
Cancer prevention	Folasire 2016 (C. Africa)	65.0
Weight loss	Al-Isa 2014 (Kuwait)	54.8
Other		
Food Label Reading	Misra 2007 (U.S.)	41.5
Cultural foods and food habits	Mcarthur 2011 (U.S)	63.0 [b]
Functional foods	Morawska 2016 (Poland)	49.8 [b]
Organic foods	Dahm 2009 (U.S.)	49.0
Mediterranean diet	Bottcher 2017 (U.S.)	73.2
Overall knowledge		
	Sajwani 2009 (Pakistan)	43.9
	Buxton 2013 (C. Africa)	44.8[b]
	Peltzer 2002 (S. Africa)	50.8[c]
	Al-Isa 2014 (Kuwait)	56.9
	Barzegari 2011 (Iran)	57.2[c]
	Crites 2005 (U.S)	~59.9
	Nabhani-Zeidan 2011[d] (Lebanon)	~62.8
	Cooke 2014 (UK)	65.5[c]
	Yahia 2016 (U.S.)	~66.3
	Kresić, G., 2009 (Croatia)	67.4[c]
	El-Sabban, 2011 (Kuwait)	72.3
	Bernardes Spexoto 2015 (Brazil)	79.7[b]

[a] An approximate number was given as different values were reported for males and females aged ≥19 years, [b] Participants were students from health-related sciences e.g. dietitians, medical, nursing, pharmacy, [c] The General Nutrition Knowledge Questionnaire was used as an assessment tool.[d] An approximate number was given as different values were given for students with a high and low socio-economic status.

According to a review undertaken by Barbosa et al. (2016), most studies aiming to assess nutrition knowledge developed their own questionnaires and estimated the level of knowledge by calculating the number of correct answers. A valid tool frequently used is the General Nutrition Knowledge Questionnaire (GNKQ), developed by Parmenter & Wardle (1999) for the UK adult population (Barbosa et al., 2016). This questionnaire assesses four aspects of knowledge, including dietary recommendations, nutrient sources of foods, healthy food choices and diet-disease relationships. The majority of studies (Table 2.3) found that students had a moderate level of knowledge in most domains by correctly answering about 45%-65% of the questions. The knowledge of students on specific nutritional domains as well as overall nutrition knowledge scores are presented below in more detail.

2.6.3 Knowledge of dietary recommendations

With respect to studies investigating the knowledge of country-specific dietary recommendations, the mean scores of correct answers of students were 51% in South Africa (Peltzer, 2002), 60% in the US (Kolodinsky et al., 2007), 66% in Lebanon (Nabhani-Zeidan et al., 2011) and 73% in the UK (Cooke & Papadaki, 2014) (Table 2.3). Regarding the recommended intakes of specific foods, students answered correctly less than 40% of the questions about FV (Matthews et al., 2016), less than 23% of the questions about milk and their alternatives (Matthews et al., 2016) and 18% of the questions about fermented dairy products (Mazier & Mcleod, 2007). Furthermore, students responded correctly about half of the questions regarding wholegrains (score 54%) (Williams & Mazier, 2013) and healthful food choices (score 47%) (Peltzer, 2002). These findings might indicate that a higher number of interventions for students have been focused on increasing intakes of FV and wholegrain and less on the intake of dairy products.

2.6.4 Knowledge of nutrients in foods

With regards to studies investigating the knowledge of macronutrients, students seem to have a moderate knowledge of carbohydrates (score 61%), fibre (score 50%), protein (score ranges 48%-72%) (El-Sabban & Badr, 2011; Al-Isa & Alfaddagh, 2014) and the different types of fats and lipids in the diet (score ranges 50%-69%) (Mazier & Mcleod, 2007; Jasti & Kovacs, 2010; El-Sabban & Badr, 2011; Al-Isa & Alfaddagh, 2014). These findings are consistent with the dietary behaviour presented earlier (Table 2.2), where students reported consuming high amounts of protein-based animal foods (meat) and exceeding the recommended fat intake.

Regarding knowledge of micronutrients, students answered correctly about 50% to 70% of the questions, demonstrating a moderate level of knowledge of the sources and functions of vitamins and minerals (Table 2.3). Two studies focused on vitamin D and students' scores were low, ranging from 29% (Boland et al., 2015) to 43% (Zhou et al., 2016). The second study was undertaken with medical students which might explain the higher knowledge score (Zhou et al., 2016). For many years, vitamin D was not emphasised in the diet, as it is mainly provided via skin exposure to sunlight. However, the last decade, research and interest in vitamin D regarding dietary sources and human requirements has been increased, due to the high number of children and adults identified with low serum levels (Scientific Advisory Committee on Nutrition, 2016). The study by Al-Isa & Alfaddagh (2014) also found a moderate level of knowledge on sodium, which again reflects the high intakes consumed by students (Table 2.2).

2.6.5 Knowledge of diet-disease relationships

When students were asked about their knowledge of the impact of diet on chronic diseases including obesity, type 2 diabetes, bowel and cardiovascular diseases, the mean score of correct answers was 45% in the UK (Cooke & Papadaki, 2014) and 43% in South Africa (Peltzer, 2002). The lowest score (13%) was found in a sub-sample (low socioeconomic status) of students from Lebanon (Nabhani-Zeidan et al., 2011). One study inquired about the dietary practices to prevent cancer and students addressed correctly 65% of the questions (Folasire et al., 2016) while another inquired about weight loss practices and students addressed correctly about half of the questions (55%) (Al-Isa & Alfaddagh, 2014). The lack of substantial knowledge regarding the implications of diet on health could exacerbate the current eating habits or motivation of young people to adopt healthier eating habits.

2.6.6 Knowledge of food labels, organic, cultural and functional foods

With regards to other aspects of nutrition, a study in the US found that students demonstrated good knowledge when asked about the Mediterranean Diet (score 73%) (Bottcher et al., 2017), indicating that the MD is well-promoted in the country. Another study in the US explored knowledge on food labels and found that students failed to answer 58% of questions about claims on food labels (Misra, 2007). These findings could be explained by the existence of multiple food labelling systems in the country (single traffic light, multiple traffic light, facts up front, NuVal and the latest 3-star rating system), which might be difficult for people to habituate (Gorski Findling et al., 2018). A qualitative study in Sweden conducted focus groups to explore the interpretation of symbols and claims on food labels by students (Neuman et al., 2014). The study concluded that students tended to consider a food item as 'healthy' based on its manufacturing methods and additives rather than on its effect on physical health and body requirements. Another study in the US explored the knowledge and consumption of organic foods by students (Dahm et al., 2009). This study reported that 51% of students did not provide a proper definition and 68% did not recognise the seal of organic foods. Organic food is usually more expensive and absent from university menus which might explain the low awareness and consumption found in the study (Dahm et al., 2009). Another study asked Polish pharmacy students about the definition, form and function of functional foods and students replied correctly less than 60% of the questions, demonstrating a moderate-to-low knowledge about this food category (Morawska et al., 2016). Finally, a study in the US among dietetic students found an inadequate knowledge when asked about foods and dietary habits of different ethnic groups (score 63%) (Mcarthur et al., 2011). Such lack of knowledge is important for dietitians' competence in practice, as it is crucial to address and incorporate individuals' cultural and racial/ethnic characteristics when designing dietary regimes or giving dietary advice.

2.6.7 Overall nutrition knowledge

Some researchers calculated the mean score of all correct answers from different nutritional domains to get an estimate of overall nutrition knowledge. As shown in Table 2.3, four studies used the same tool or an adapted version (GNKQ) to assess overall knowledge (Peltzer, 2002; Kresić et al., 2009; Barzegari et al., 2011; Cooke & Papadaki 2014). The mean scores of correct answers in these studies ranged from 51% to 67%, suggesting a moderate level of overall knowledge. The remaining studies found similar trends, with the lowest mean score (43.9%) reported in Sajwani et al. (2009) and the highest score (79.7%) in Bernardes Spexoto et al. (2015). It is worth mentioning that the first study included only non-medical students while the second included only pharmacology and biochemistry students. This implies that field of study seems to affect the level of nutrition knowledge, which is further illustrated below.

2.6.8 Factors affecting nutrition knowledge

Field of study seems to be a factor associated with nutrition knowledge although contradictive data exists. Students from health-related sciences such as Medicine or those having prior nutrition education found to have significantly greater levels of knowledge when compared with students from theoretical sciences such as Political, Art and Social Sciences (Bernardes Spexoto et al., 2015; Boland et al., 2015; Bottcher et al., 2017). However, similar studies found that prior nutrition education or studying a health-related course did not significantly impact knowledge (Buxton & Davies, 2013; Matthews et al., 2016). Year of study might also affect the level of knowledge as in many studies, older students had greater knowledge compared to first year or junior students (Mazier & Mcleod, 2007; Kresić et al., 2009; Al-Isa & Alfaddagh, 2014; Bernardes Spexoto et al., 2015). Gender is also a predictor, as a high number of studies reported that females had significantly higher levels of knowledge compared to their male counterparts (Peltzer, 2002; Misra, 2007; Kresić et al., 2009; Jasti & Kovacs 2010; Bottcher et al., 2017), although there is a limited number of studies contradicting these findings (Folasire et al., 2016) or where no association between knowledge and gender was found (Barzegari et al., 2011; Buxton & Davies, 2013). This variation might be explained by the fact that some health-related courses (e.g., Nursing, Midwifery) which usually include some nutrition exposure, are female-dominating while Political, Maths, Engineering and Business courses are male-dominating. It could also be explained by the fact that women are more motivated to look for health-related information compared to men (Ek, 2015). Other studies found that high socioeconomic status (Nabhani-Zeidan et al., 2011), healthy BMI (Sajwani et al., 2009), ethnicity (non-

Hispanic white) (Jasti & Kovacs, 2010), living alone, preparing own food (Kresić et al., 2009), being a grocery shopper (Jasti & Kovacs, 2010) as well as having good dental hygiene and high academic achievement (Al-Isa & Alfaddagh, 2014) were positively associated with greater nutrition knowledge in university students. However, none of these studies were undertaken in Europe, therefore, more UK-based studies are needed to explore the association of academic and socio-demographic characteristics and nutrition knowledge of students.

2.7 The Health Promoting University Initiative

In 1998, the WHO announced that 'the University should protect and promote the health and wellbeing of its community (students and staff) by applying health promoting practices in order for individuals to achieve their full potential' (Tsouros et al., 1998). In 2015, the Okanagan International Charter for Health Promoting Universities (HPU) and Colleges launched an action framework for Higher Education Institutions (HEIs) and a set of series of Call to Actions for Universities to adopt the Initiative (American College Health Association, 2015). Following the paradigm of Okanagan Charter, a small community of UK HEIs initiated the Healthy Universities Network and currently, the network includes 64 members from across England and 24 members from outside the UK (www.healthyuniversities.ac.uk). The Network is led by Professors Mark Dooris and Sue Powel and is financially supported by the University of Central Lancashire and Manchester Metropolitan University. The Model and Framework for Action of the Healthy Universities Network is presented in Figure 2.1.

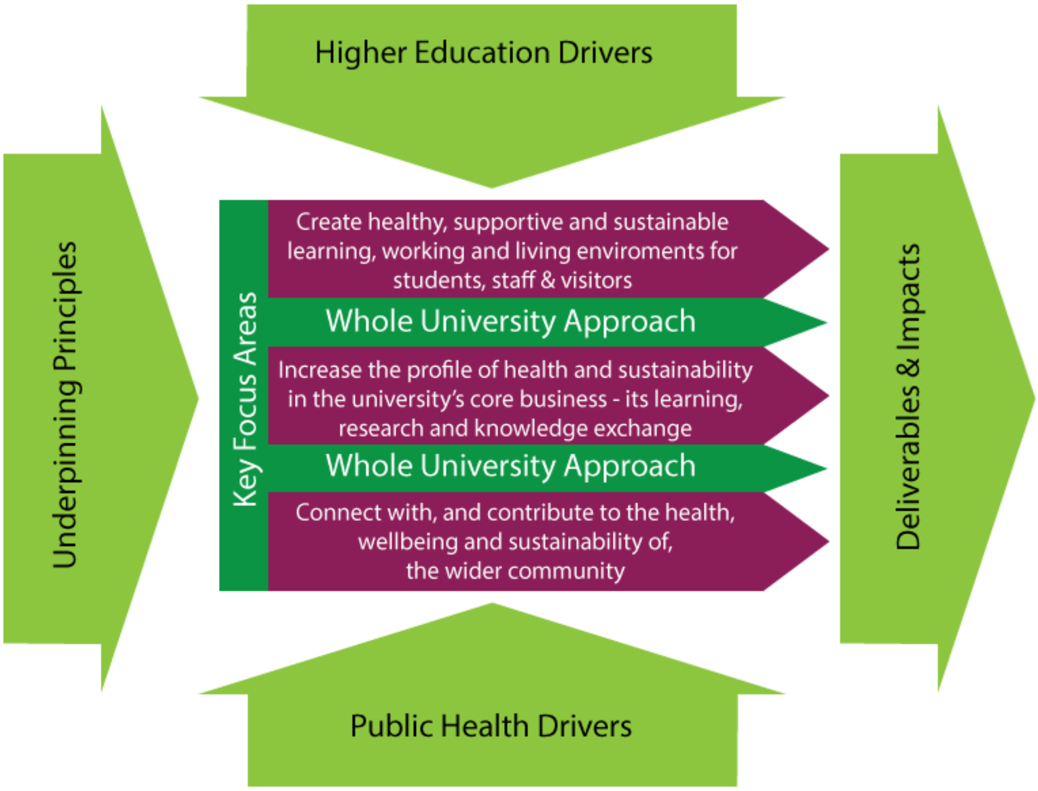


Figure 2. 1. Healthy Universities Concept, Model and Framework
Figure source: [Healthy Universities: Concept, Model and Framework for Applying the Healthy Settings Approach within Higher Education in England]

The HPU initiative has been adopted by other HEIs globally based on a recent published review which reported that 27 HEIs in Europe, 24 in US and 3 in other countries (Australia, Africa) have implemented activities based on the Initiative (Suarez-Reyes et al., 2018). However, very few HEIs have applied a holistic approach targeting multiple areas of actions (Table 2.4). Activities to promote physical activity and healthy eating habits were reported as part of the HPU approach including courses on physical activity, collaboration of the university with the sports centres or amendments in catering services of university's cafeterias (Suarez-Reyes et al., 2018). Although the

Healthy Universities Framework is a multi-faceted approach, with exercise and eating behaviour being only a small part of the physical, mental, emotional and social well-being, interventions that have a positive impact on physical activity and dietary behaviour of university students could provide substantial information towards the HPU's actions and deliverables.

Table 2. 4. Areas of action of a Healthy Promoting University approach

Areas of action	Example of activities
Skills for health and well-being	Training courses, workshops, peer-training, opportunities for extracurricular activities, etc.
Support research in health promotion	Promotion of research (dissertation, thesis) on health-related topics
Healthy polices	Regulations to promote healthy eating habits, practice of physical activity, restrict alcohol, etc.
Healthy working environment	Provide safe workplace
Healthy study environment	Safe physical environments (cafeterias, library, study spaces), cultural spaces and activities, sports centre.
Partnership and links	Collaboration with other health organisations (WHO, NHS, public health of England), universities, schools.
Health in curriculum	Courses on health promotion
Postgraduate training in health promotion	Specialised courses, masters, PhDs focused on health promotion
Re-orientation of primary health care	Activities to promote physical, psychological and emotional well-being

Source: The content of table was sourced and adapted from Suarez-Reyes et al. (2018)

2.8 The potential of the use of internet in health education and promotion

According to the Office for National Statistics in the UK in 2018, 90% of adults and almost all (99%) adults aged 16 to 34 years were internet users (Office for National Statistics, 2018). Most people searching online for health information are those who suffer or have been recently diagnosed with a disease, however, there has been an increase in healthy users seeking information about diet, fitness and exercise (Mo, 2012). A large Monitoring Survey in Australia found that between 1995 and 2012 the use of the Internet as a source of nutrition information increased from less than 1% to 34% (Pollard et al., 2015). The same survey reported that in 2012, 57-59% of females and 33-36% of males aged 18-34 years used the Internet to extract nutrition information. Besides sourcing information, the internet has been used to promote health in individuals. The meta-analysis by Webb et al. (2010) identified 85 RCTs using an internet-based approach to improve health behaviour in adults. The meta-analysis found a small but significant effect (d=0.16, 95% CI: 0.09-0.23) which was enhanced when the interventions were based on behaviour-change theories.

Using the internet to educate and promote health has many advantages, as it provides a low-cost source of information and reduces the expenses needed compared to face-to-face interventions (Mo, 2012). It also enables to reach a high number of recipients and overcomes geographical boundaries, implementing distant-learning or interventions in small or large groups of people or providing tailored information and advice (Mo, 2012). Studies also found that the anonymity offered by the internet helped hesitant individuals to seek professional advice or get more information such as those stigmatised with a disease (Davison et al., 2000). The internet provides further the opportunity of social interaction via social media platforms (Facebook, Instagram, forums, etc.) which also plays a significant role in health literacy and behaviour of individuals (Roberts et al., 2017).

Despite the advantages of the internet, there are also concerns regarding its use. Firstly, not everybody has access to the internet and have the skills to use it, although this prevalence is very low in developed countries and more evident in older people (Mo, 2012). The biggest issue, however, is the low accuracy and validity of information provided. Sutherland et al. (2005) identified 500 websites providing nutrition information and assessed their content quality, usability and readability. The authors concluded that the websites derived from popular search engines had significantly lower data accuracy, were more user-friendly as well as easier to navigate and read. One main omission was the use of references when providing nutrition information and not referring both positive and negative aspects when analysing a nutrition topic (e.g. use of vitamin supplements to prevent a disease) (Sutherland et al., 2005). The fact that the internet enables anyone who wishes to upload information and create their own websites and platforms and, furthermore, pay to get more hits, is a great disadvantage of the world wide web and for its users who seek valid information. To overcome this bias, internet-users should be educated to recognise and visit websites with valid sources of nutrition information (mostly governmental or institutional sites) or facilitators of the world wide web need to establish standards to evaluate the health information uploaded by individuals (Sutherland et al., 2005).

2.9 Aim and Objectives of the research project

The evidence presented in this chapter highlight that the period from high school to university, as well as the years students are enrolled at university, are important due to the unfavourable changes occurring in their dietary and physical activity behaviour. University students tend to decrease their amount of physical activity and consume convenient and energy-dense foods. These behaviours lead to weight gain and have been associated with negative implications on students' health. Universities should undertake actions and activities to promote the well-being and health of their communities, as stated by the HPU Initiative. The world wide web provides great potential to implement low-cost and easily accessible interventions within HEIs to increase nutrition knowledge and promote healthy students' lifestyle behaviours. As a result, the effectiveness of web-based interventions compared to other modes of interventions needs to be further explored.

This research project will apply appropriate research methods (Chapter 3) to identify the effectiveness of the different types of interventions targeting weight-related outcomes in university students. Furthermore, it will provide insights into the nutrition knowledge of students of two UK-based HEIs and investigate whether a web-based intervention improves nutrition knowledge as well as dietary and physical activity behaviour, in a sample of university students. The following were the objectives of the research project:

Objective 1: Identify the existing different types of interventions targeting dietary, physical activity and weight-related outcomes in university students and investigate their effectiveness by undertaking a systematic review of systematic reviews (overview) (Chapter 4).

Objective 2: Provide new evidence with regards to the level and gaps of knowledge on various nutritional domains, the factors and predictors associated with a good level of knowledge and whether nutrition knowledge is associated with an increased diet quality, in a sample of university students in the United Kingdom (Chapter 5).

Objective 3: Provide new evidence with regards to the design, implementation and evaluation of a web-based educational programme with quiz-games (e-programme) and investigate its impact on nutrition knowledge, diet quality and physical activity, in a sample of university students in the United Kingdom (Chapter 6).

Chapter 3 illustrates the **Research Methods and Procedures** applied in the current research project to address each of the objectives.

Chapter 3. Research Methods and Procedures

3.1 Overview of the chapter

Chapter 3 presents the methodological framework of the research project, including the philosophical theories underpinning the research design. A brief description and justification of the different study designs applied to investigate each of the research objectives is provided. The population of interest of the research, including the calculation of sample size and its eligibility criteria as well as the applied recruitment processes are also described. The main outcomes of each study are presented as well as a detailed description, justification and validation of the methods and tools used for data collection. A brief description of the general steps and procedures used in the research project for data processing and analysis is presented in this chapter, although more details about the methodology of each study and statistical analysis of its variables are presented within chapters 4, 5 and 6. Chapter 3 concludes with the ethical considerations of the research project, including the methods used for handling data and a reflection of potential risk for participants, funding sources and the ethical approval sought for each component of the study.

3.2 Philosophical framework of methodology

Epistemology is the philosophical study of theories and ways of gaining knowledge, including many branches that shape the methodology scientists use to acquire and justify knowledge (Carter & Little, 2007). Rationalism is a branch of epistemology supporting that knowledge is based on reason and theoretical deduction rather than empirical observation. On the other hand, the theory of Empiricism supports that knowledge is acquired based on observations and sense-experiences rather than by making assumptions or predictions (Carter & Little, 2007). The theory of Positivism, which combines elements from Empiricism and Rationalism (Mill, 1865), indicates that knowledge is acquired via observable, empirical and measurable evidence supported by reasoning. The above theories constituted the conceptual framework of the methodology used in this research project, where inductive reasoning was used to formulate hypotheses, empirical methods to test their correctness and deductive reasoning to apply them to specific situations.

3.3 Systematic review of the literature (overview)

The scope of a systematic literature review and meta-analysis is to identify studies that are fulfilling predefined eligibility criteria to inform or pool together existing evidence in a specified field to help decision-making (Van et al., 2012). It is good practice before conducting a systematic review or meta-analysis to register its protocol on a database (https://www.crd.york.ac.uk/prospero/) to describe in detail the guidelines that will be followed and prevent other researchers undertaking the same review (Booth et al., 2011). In comparison to plain reviews, systematic reviews and meta-analyses follow specific standards that increase the methodological quality and reduce random and systematic errors of bias (Dickersin & Berlin, 1992). Such standards have been developed by many scientific groups such as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Group (Mother et al., 2009) or the Institute of Medicine (Institute of Medicine, 2011).

In the past decade, many interventions aimed at improving weight-related outcomes in university students have been implemented and a plethora of studies have been summarised in systematic reviews (Plotnikoff et al., 2015; Laska et al., 2012). Despite the general increase in numbers of systematic reviews, it is unknown whether these are of good quality and enhance the knowledge needed for evidence-based practice (Ioannidis, 2016). An additional challenge is that the outcomes and interventions of these studies vary considerably, making the synthesis of results challenging. As more than one attempt has been made to synthesise studies aiming to improve dietary, physical activity and weight-related outcomes in university students, conducting a systematic review of systematic reviews (reported hereinafter as 'overview') was an appropriate method to provide information on the overall effect of the existing types of interventions toward these outcomes and to identify gaps in research which informs new knowledge and practice (objective 1 of the thesis). For the purposes of the overview, the PRISMA guidelines were followed. Specific quality criteria (AMSTAR 2) were used to praise the methodological quality of the overview (Shea et al., 2017) while a meta-analysis was not feasible due to the diversity of the identified interventions and outcomes. The aims and objectives, methods used, and findings of the overview are presented in detail in Chapter 4.

3.4 Quantitative research and study designs

Empirical methods, including quantitative research, were used to investigate the objectives and the validity of the generated hypotheses of each study of the research project. Quantitative research is used to test hypotheses and study well-known phenomena under controlled conditions in large datasets of individuals (Creswell, 2014). The findings derived from quantitative research are numerical data which can be statistically analysed to explore the impact of interventions on specific outcomes (Harris et al., 2009). In this research project, the empirical methods undertaken included a cross-sectional study and a randomised controlled trial.

Cross-sectional studies are part of observational studies (Pandis, 2014) and are used to describe characteristics of a studying population at a specific point in time as well as the possible associations between factors and the outcomes of interest (Parab & Bhalerao, 2010). Cross-sectional studies are in general quick, easy and inexpensive to conduct and can contribute to the generation of hypotheses and inform the design of interventions. On the other hand, they are susceptible to recall bias, unable to establish causal relationships and prone to high non-response rates (Pandis, 2014). In this research project, a cross-sectional study, which included an online questionnaire, was conducted to explore the current level of nutrition knowledge (expressed as the sum of correct answers to questions), factors (demographic, academic, etc.) and predictors associated with good knowledge as well as the potential association of knowledge with diet quality, in a sample of university students in the UK (objective 2 of the thesis). The preliminary findings of this study were also used to inform the design of the RCT of the research project (objective 3 of the thesis). The aim and objectives, methods used, and findings of the cross-sectional study are presented in detail in Chapter 5.

Randomised controlled trials are a subset of interventional trials, where individuals are randomly allocated to a group that receives the intervention (intervention group) and a group that receives the standard, different, placebo or no treatment/intervention (control group) (Kendall, 2003; Kabisch et al., 2011). Random allocation to groups reduces potentially confounding factors (e.g. age, gender) and their effect on the endpoints (Kabisch et al., 2011). Randomised controlled trials are considered the most rigorous method in nutritional research to investigate the effectiveness of an intervention (Willet, 2012). In this research project, a randomised controlled trial was conducted to investigate the impact of an online educational intervention including a website and ten quiz-games (reported hereinafter as e-programme) on dietary and physical activity outcomes in a sample of university students in the UK (objective 3).

Double-blinded RCTs are a type of RCTs where both the researchers and the participants are unaware of the group allocation and intervention assigned to participants (Kabisch et al., 2011). Although this type of RCT reduces bias related to subjective predispositions towards the intervention, in nutritional research it is not always feasible to blind participants, for instance in cases were individuals are asked to change their dietary behaviour. In this research project, the participants were randomised in two groups - the intervention group, which received information through an online intervention and the control group, which received no information at all. Since the students in the intervention group gained access to the e-programme and the research was conducted by one investigator, it was not possible for practical and ethical reasons to undertake a double-blinded RCT.

Other considerations when undertaking a RCT are the appropriate duration of the intervention to cause a change in the desired outcome and the low adherence of participants to the intervention which might distort the impact of the intervention on the outcome (Willet, 2012). In this research project, the duration of the intervention was ten weeks based on the rationale that students would play one quiz-game per week (see Chapter 6 for details of the e-programme). This duration gives students enough time to engage with the e-programme without burdening their study or leisure time, as well as improve or change their dietary and activity behaviour, as shown in similar studies (Grim et al., 2011; Kattelmann et al., 2014). Adherence to the e-programme was calculated to explore whether it had an impact on the outcomes of the study (see Chapter 6). A follow-up study to investigate whether any changes on outcomes maintained at a later stage was not conducted as part of this research project due to time and financial restrictions. The aims and objectives, the methods used, including the rationale and development of the e-programme, and the results of the RCT are described in Chapter 6.

At the end of the RCT, an online follow-up questionnaire was sent to participants who engaged with the e-programme to explore their perceptions regarding their motivation to participate in the programme, the characteristics (content, duration, mode of delivery, etc.) of the programme, the impact of the programme on their knowledge, and the programme's accessibility, feasibility, value and sustainability. Participants in the control group and those who did not engage with the e-programme did not receive this follow-up questionnaire. The follow-up questionnaire included open-ended questions, where students could write and expand their thoughts, and closed-ended questions with various statements, where students had to select a response based on a 4-scaling coding-scheme to express their feelings/thoughts (Appendix I.F). The findings of the evaluation study also contributed in explaining the results of the RCT. The methods and results of the evaluation study are presented in Chapter 6.

Although some qualitative research (in the form of open-ended questions in the follow-up questionnaire) was undertaken as part of this research project, the methodology of the thesis cannot be regarded as a mixed methods design. In mixed methods research, qualitative methods are applied before, after or at the same time with quantitative methods in order to enhance, clarify or triangulate the findings of quantitative research (Johnson & Onwuegbuzie, 2004). Qualitative methods include in-depth interviews and focus groups in order to explore individuals' perceptions and interactions or investigate little-known phenomena using a small number of individuals (Harris et al., 2009). However, no such qualitative methods were used in this research and the data from the evaluation study was predominately analysed as quantitative by calculating the means and standard deviations of the perceived ratings in each statement provided by students (Chapter 6).

3.5 Sampling methods

3.5.1 Population and settings of the research

The population of interest in this research project was university students due to the unfavourable weight changes and unhealthy dietary and physical activity behaviours reported while studying at university, as presented in the **Literature Review** (Chapter 2). For the purposes of this research, two UK HEIs were used to recruit students. The participating universities were Kingston University, London (KU) and St George's, University of London (SGUL). Both Universities are located in South London.

KU offers a variety of disciplines which, at the time of the research, were provided through the following five Faculties: a) Arts, Design and Architecture, b) Arts and Social Sciences, c) Business and Law, d) Science, Engineering and Computing and e) Health, Social Care and Education. SGUL is mainly a medical school affiliated with St George's University Hospitals NHS Foundation Trust and offers Medicine and

Biomedical Sciences. It also shares the Faculty of Health, Social Care and Education with KU, offering the following healthcare courses: Midwifery, Nursing, Occupational Therapy, Paramedicine, Radiography, Rehabilitation Sciences and Social Work and Social Care. The two universities provided the opportunity to recruit students from different scientific disciplines and allowed to investigate for potential differences in outcomes between the different disciplines. Also, both universities enrolled students from different countries and ethnic backgrounds and promoted diversity. Both universities were equipped with state-of-the-art facilities which allowed and supported the safe conduct of the research.

The students' profiles of KU for the academic years 2016/7 and 2017/8 period, during which the research took place, are presented in Table 3.1. The students' profiles of SGUL were requested by the researcher but the institution opted to not disclose this information. Based on the data collected for the 2018 World University Rankings, SGUL had enrolled a student body of 3,174 students of which 62% were female and 38% male.

Table 3. 1. Facts and figures of the student population at Kingston University for the academic years 2016/7 and 2017/8

Faculty	**Number of students, n (% of the whole population)**	
	Academic year 2016/7	Academic year 2017/8
Arts and Social Sciences	3,738 (18.8)	3,160 (18.0)
Health, Social Care and Education	2,984 (15.0)	2,850 (16.2)
Business and Law	3,442 (17.3)	2,296 (13.1)
Art, Design and Architecture	2,675 (13.4)	2,801 (16.0)
Science, Engineering and Computing	7,054 (35.5)	6,440 (36.7)
Total	19893 (100) *of which 57.1% female, 42.7% male and 0.25% other*	17547 (100) *of which 57.7% female, 42% male and 0.32% other*

Source: Kingston University Records System corresponding to the higher Education Students' Early Statistics (Survey census date available at https://www.kingston.ac.uk/aboutkingstonuniversity/factsandfigures/studentprofiles/.

3.5.2 Eligibility criteria of the sample population

All students enrolled during the academic years 2016/7 and 2017/8 at KU or SGUL were eligible to participate in the research, independent of their mode of attendance (part-time or full time) and studying status (undergraduate or postgraduate). For the cross-sectional study, there were no exclusion criteria and all students (except those who were working in parallel as staff) were eligible to take part in the study. For the RCT, the following inclusion and exclusion criteria were applied:

- Students aged 18-34 years were included because the period between 18 and 34 years of age has been found critical for unwanted weight gain (Williamson et al., 1990).

- Students with a (known) long-term disease or condition that required special treatment or diet were excluded. It is possible that individuals with medical conditions might require special dietary treatment which might impact the outcomes of the study.
- Women known to be pregnant or breastfeeding were excluded because of their special nutritional requirements.
- Students with mobility impairments or injury or those who could not perform safe levels of activity were excluded. Students were screened for their readiness to perform a safe level of exercise using the Physical Activity Readiness Questionnaire (PAR-Q) (Thomas et al., 1992) (Appendix I.A), as the intervention suggested moderate levels of physical activity. Those with positive answers to one or more of the PAR-Q questions were excluded from the study.
- Students with risk of eating disorders were excluded due to their disturbed relationship with food. Students were assessed whether being at risk of eating disorders using the SCOFF (Sick, Control, One stone, Fat, Food) questionnaire (Morgan et al., 1999) (Appendix I.B). Those at risk (two or more positive answers in the questionnaire) were excluded from the study and advised to refer to their general practitioner for further consultation.

3.5.3 Sample size

Sample sizes for the cross-sectional study and the RCT were calculated based on a score of nutrition knowledge, which was one of the primary outcomes in both studies.

3.5.3.1 Sample size of the cross-sectional study

The sample size was calculated based on the accuracy (i.e. standard error) of the estimated mean score of nutrition knowledge in the population of interest. According to Kliemann et al. (2016), the standard deviation (SD) of the knowledge score of non-dietetic students is 9.2. As shown in Figure 3.1, assuming a mean score of 65 in our sample (knowledge scores range from 0-88) and a SD of 9.2, the larger the sample size, the lower the standard error (SE) and the range of confidence intervals (CI±2SE) of the mean score. Figure 3.1 shows the number of participants needed based on the confidence intervals (lower and upper levels) of a 65-mean score of nutrition knowledge. For the purposes of this study, 200 participants would be a sufficient sample size.

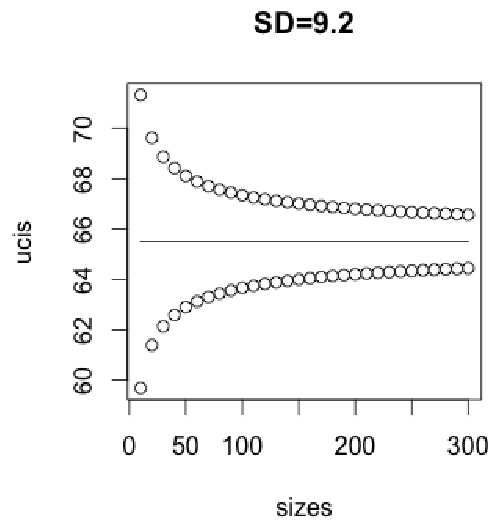


Figure 3. 1. Sample sizes of the cross-sectional study

3.5.3.2 Sample size of the randomised controlled trial

The sample size was calculated based on nutrition knowledge score as presented by Kliemann et al. (2016). Construct validity of the questionnaire was tested by comparing the mean scores in students studying Dietetics (n=96) versus English (n=89). The total mean score was 79.3 (SE: 0.51) for students studying Dietetics and 67.7 (SE: 0.97) for students studying English. The overall score difference was 11.5 points (95% CI: 9.3-13.7), which represented a large-sized effect (d=1.2). According to this data, the standard deviations would be approximately 5 for the students studying Dietetics and 9 for the students studying English. Since there are no established thresholds to indicate a minimum clinically important difference for knowledge, an 8%-9% (7.0-8.0 points) increase on the initial score would significantly improve diet quality, as suggested by Kullen et al. (2016). In particular, Kullen et al. (2016) found a 7.6% difference in the mean scores between two military groups that had significant differences in their nutrition knowledge scores. As students from both healthcare and non-healthcare faculties were invited to participate in this study, a standard deviation between 7 and 9 was expected in the mean scores of this population. Setting the power at a 90% level and significance threshold at $p<0.05$, a sample size of at least 35 participants in each group would satisfy the above criteria. Considering a 25% drop out rate, the overall sample size needed for this study was 88 participants.

3.5.4 Recruitment process

In general, the Student Union societies (via newsletters, social media, etc.), the intranet websites of KU (StudySpace) and SGUL (Moodle) and the Universities' facilities (e.g. cafeterias, gym) were used to recruit participants. A special email address (uni-smarteating@hotmail.com) was created to enable potential participants to interact with the Principal Investigator (PI) and to ask questions about the studies before enrolling.

The cross-sectional study was advertised through a post on the intranet websites of the two universities and an email was sent to all students by the course-directors of all faculties. The advert message included a brief explanation of the study's aims and procedures and the link to the study's online questionnaire. Once opening the link to the questionnaire, the participant information sheet would open and potential participants were advised to read it carefully. The participant information sheet included the aims of the study, details about what potential participants would have to do if they agreed to participate, benefits and risks of taking part and how their data would be handling. The participant information sheet was followed by a consent form and before entering the questionnaire of the study, participants had to agree (by clicking) with all the consent statements on the form. The voluntary nature and anonymity of participating was emphasised in the consent form. The advert was available until the optimal number of participants was reached (about one year).

The RCT was advertised using the three following methods: 1) displaying posters advertising the study in common areas at both universities, 2) an announcement of the study on the intranet websites and 3) emails sent to students via the course directors at both universities. The voluntary nature of participating was emphasised. Contact details of the PI were presented on the advert material and volunteers were encouraged to make contact to express their interest and/or ask questions. Once a potential participant made contact, the PI send via email an invitation letter including the participant information sheet of the study. Contact information of the PI and the primary academic supervisor were also provided. Potential participants were asked to carefully read the forms and discuss it with relevant third parties if they wished. After one week, students were contacted by the PI to inquire about their decision to participate. Those who agreed to participate were further screened against the eligibility criteria and if eligible, a consent form was given to read carefully and sign it. Eligible participants were then randomised to the intervention group or the control group.

Randomisation was done by using computer-generated random numbers (Urbaniak & Plous, 2015). It was expected that more participants from the intervention group would drop out, therefore the allocation ratio of the two groups (intervention: control) was 4:3. Due to ethical restrictions, the participants were informed about the existence of both groups of the study prior to their consent, thus blinding was not possible.

3.6 Data collection methods

3.6.1 Main outcomes of research

With regards to the objectives of the research project, the primary outcomes were:

- Nutrition knowledge
- Diet quality, and
- Physical activity.

Secondary outcomes, including factors that might impact the above outcomes or act as confounders, were:

- Health indicators
- Socio-demographic factors.

3.6.2 Nutrition knowledge

The most common method for assessing nutrition knowledge in university students is the administration of questionnaires with closed-ended questions (Yahia et al., 2016; Folasire et al., 2016). These questionnaires might focus on specific nutritional aspects, such as knowledge on vitamin D (Boland et al., 2015) or wholegrain products

(Williams & Mazier, 2013) or assess multiple domains of nutrition knowledge, such as fibre, fat and diet-disease relationships (Bernardes Spexoto et al., 2015). Less used methods include asking questions through a quiz with multiple-choice questions (Zhou, 2016). To our knowledge, there are no established criteria or thresholds to indicate a good from a poor level of knowledge. Nutrition knowledge is mainly rated by calculating a score summed from the closed-ended questions where, in most cases, a higher score indicates a higher level of knowledge (Kresić, et al., 2009; Cooke & Papadaki 2014). In some studies, researchers calculated the overall mean score of knowledge of their sample and defined as 'high knowledge' any score above that level (Yahia et al., 2016; Folasire et al., 2016). In other studies, researchers calculated the percentage of respondents with correct answers (Dahm et al., 2009) or the percentage of correct answers on the questions (Bernardes Spexoto et al., 2015) to get an estimate of the level of nutrition knowledge of their participants.

In this research project, nutrition knowledge was an outcome of interest in both studies. The General Nutrition Knowledge Questionnaire (GNKQ) was used to assess the level of knowledge among university students. The GNKQ was originally developed by Parmenter & Wardle (1999) for adults in the UK and included 110 questions in total. The questionnaire investigated the following aspects of nutrition: dietary recommendations (section 1), nutrients in foods (section 2), healthy food choices (section 3) and diet-disease relationships (section 4). The GNKQ was revised in 2016 by Kliemann et al. (2016) to include updated evidence from the nutrition field, and the total number of questions was reduced to 88 (GNKQ-R). In particular, questions on oily fish, alcohol intake, breakfast, fruit juices and starchy foods were added to section 1; questions on food sources of salt (e.g. breakfast cereals), added sugars (e.g. soft drinks), trans-fat and processed foods were added to section 2; questions on cooking methods and food labelling were added to section 3 and questions on glycaemic index, body shape and optimal practices to maintain a healthy body weight were added to section 4. The old version of the GNKQ included a mixture of closed-ended and open-ended questions where respondents could expand on their yes/no responses to questions such as '*What diseases or health problems do you think are related to fat*'. The revised version of the questionnaire did not include open-ended questions and all questions were multiple-choice questions. One could argue that open-ended questions could contribute to a better understanding of students' knowledge and reduce bias due to the possibility of choosing the correct answer by chance. However, including updated evidence-based information on nutrition was regarded as more important for this research project. Additionally, the questionnaire was quite lengthy (estimated time for completion was 15-20 minutes) which might result in high non-completion rates, therefore the shorter and revised version of GNKQ was preferred. The original GNKQ has been used before to assess knowledge in higher education settings (Kresić et al 2009; Cooke & Papadaki, 2014) but to our knowledge, this is the first study using the revised version to assess nutrition knowledge in university students.

3.6.2.1 Validation of the GNKQ-R questionnaire

The developers of the GNKQ-R conducted a validation study to assess its reliability (Kliemann et al., 2016). Both internal consistency (Cronbach's Alpha > 0.7) and external reliability (intraclass correlation coefficient >0.7) was found high in all nutritional sections. Since the questionnaire highly reflects the objectives of this research project, no further validity tests were conducted. However, five students were invited to participate in a pilot study to estimate the feasibility of the questionnaire. After the pilot study, a few students asked to re-phrase the following two questions to increase clarity:

- Original question: Which of the following nutrients has the most calories for the same weight of food?
- Amended question: Which one of the following nutrients has the most calories per gram?
- Original question: If a person wanted to reduce the amount of fat in their diet, but didn't want to give up chips, which of the following foods would be the best choice?
- Amended question: If a person wanted to reduce the amount of fat in their diet, which chips would be the best choice to eat?

In addition, the original questionnaire included questions on marital status, number of children and educational level. These questions were removed and replaced by questions related to age, university, faculty, studying status (undergraduate, postgraduate), living arrangement and being a smoker or not. SurveyMonkey® (https://www.surveymonkey.com/) was used to administer the questionnaire online however its content and structure remain unchanged. The average time for completing the questionnaire was 15 minutes. The administered GNKQ-R questionnaire is presented in Appendix I.C.i.

3.6.3 Diet quality

Common subjective methods of dietary intake assessment include 24-hour recalls, food records and FFQs (Willet, 2012). Recalls pose guided open-ended questions about the intake of foods and fluids over the last 24-hours (Conway et al., 2003). Food diaries record the intake of foods and fluids for a short period of time (e.g. 3-4 days) while FFQs include a checklist of questions on the frequency of consuming foods with closed-ended responses (never/once a day/1-2 times per week/3-4 times per week, etc.) (Boucher et al., 2006). Each of the above methods has strengths and limitations in relation to easiness of application, accuracy of intake, recall bias, cost-effectiveness, training skills and literacy level of respondents (Shim & Kim, 2014). While the 24-hour recall and food records are optimal methods to capture actual dietary and nutrient intake for a specified period of time, the FFQ is better for assessing 'habitual' intake over a prolonged period of time (e.g. six months) (Shim & Kim, 2014). FFQs can be self-administered or completed via interview by trained personnel. Food lists in FFQs sometimes include portion sizes (called semi-quantitative FFQs) and average dietary intake can be calculated by multiplying the frequency of a consuming food by the amount of food [e.g. eating 2 portions of fruit 5 times a week equals 10 (2x5) portions per week] (Willet, 2012).

In this research project, dietary intake was an outcome of interest in the RCT. The aim of the study was to capture overall diet quality of students using a quick, easy and cost-effective method rather than undertaking an in-depth analysis of nutrient intake of individuals. To achieve that, the semi-quantitative FFQ developed by Leppälä et al. (2010) was used. The FFQ included questions in relation to the intake of:

- Whole grain products (3 questions)
- Fat containing foods (4 questions)
- Dairy products (2 questions)
- Fruits and vegetables (4 questions)
- Sugary foods (4 questions)
- Meal patterns (1 question)

Some questions were multiple-choice. For instance, the answers to the question 'the bread you usually eat' were a. rye bread or crisp bread, b. whole-grain bread, c. white bread or 4. I don't eat bread. Other questions captured the frequency of foods consumption, e.g. '*How many days per week do you eat vegetables?*' and respondents had to write their responses in a text box and not choose from given multiple-choice answers. Some food frequency questions were followed by relevant questions on portion sizes. For instance, the above question was followed by '*How many portions of vegetables do you consume daily?'* In addition to recording frequency and amount of intake of foods, a score was calculated to provide an Index of Diet Quality (IDQ), as suggested by the authors of the questionnaire (Leppälä et al., 2010). In general, responses close to the recommended dietary intakes were scored with one point otherwise a null point or a point less than one was given. A summative score equal or less than 9 indicated a poor diet quality while a score from 10 to 15 indicated a good diet quality.

As presented in the **Literature Review** (Chapter 2, sections 2.5.2 and 2.5.3), the dietary habits of university students are characterised by low intakes of nutrient-dense foods such as fruit, vegetable, wholegrain and dairy products and high intakes of foods rich in fats and added sugars as well as skipping meals (Yahia et al., 2015). The IDQ developed by Leppälä et al. (2010) reflects important components of diet that should be improved in a youth population according to the UK EatWell Guide shown in Figure 3.2 (Public Health of England, 2016). Therefore, it was regarded as a suitable tool to use in this research project to assess changes in diet quality of university students before and after the implementation of the e-programme in the RCT. IDQ was also used to explore the potential relationship of nutrition knowledge with diet quality in the cross-sectional study. Diet Quality Indexes such as the US Healthy Eating Index (Kennedy et al., 1995), have been developed and used in many nutritional studies to assess diet quality and adherence to dietary recommendations (Haines et al., 1999; Kim et al., 2003).

Figure 3. 2. The Eatwell Guide depicting the recent UK dietary guidelines.
Source: Public Health England (2016)

3.6.3.1 Validation of the IDQ questionnaire

The development and validation of the IDQ questionnaire is described in detail by Leppälä et al. (2010). The original FFQ included 55 questions and evaluated the dietary habits of a Finnish population (n=103). The FFQ was validated against 7-day food records using portion picture booklets. The data collected from the records were entered into a Nutrition software package and analysed to calculate mean nutrient intakes. A Receiver Operating Characteristic (ROC) curve analysis was used to select the set of appropriate questions from the original FFQ to create the IDQ questionnaire and establish their cut-off points indicating a good or poor diet quality (Kamarudin & Kolamunnage-Dona, 2017). The IDQ scores were correlated to mean nutrient intakes calculated from the records. Higher IDQ scores were significantly correlated with healthier intakes of protein (r=0.35), fibre (r=0.42), calcium (r=0.39), iron (r=0.31), vitamin C (r=0.31), saturated fats (r=-0.22) and sugars (r=-0.25) (Leppälä et al., 2010). The ROC analysis found that IDQ had a sensitivity of 0.67 and a specificity of 0.71 compared to food records, which is considered moderate (Parikh et al., 2008).

The authors of the IDQ suggest that the questionnaire can be used in nutritional studies and applied in countries that follow dietary guidelines similar to the Finnish guidelines. The Finnish dietary guidelines (Nordic Council of Ministers, 2014) are in alignment with those suggested by the UK with the exception of dairies, where the UK suggests a moderate consumption without specifying the quantity while Finnish dietary guidelines are more precise, suggesting 500-600 ml of milk and 2-3 slices of cheese daily. Both countries, however, recommend choosing low-fat options instead of full-fat dairy products.

Five students were invited to participate in a pilot study before the main research to estimate the feasibility of the IDQ questionnaire. After the pilot study, the following amendments took place to reflect the UK dietary guidelines and increase the accuracy of collected data:

- Examples of UK foods were added in question number 5, asking about the type of spread one uses with bread.
- In question number 8, asking about the fat content of the milk one usually drinks, the following changes were made on the multiple-choice answers, considering the UK availability of products and dietary habits:

1. The answer 'full milk' was replaced with 'whole milk'
2. The answer 'semi-skimmed milk or sour milk, with 2.5% fat' was replaced with 'semi-skimmed milk (1.5-1.8% fat) or almond or soya milk'
3. The answer 'milk or sour milk with 1% fat' was replaced with 'milk with 1% fat'
4. The answer 'skimmed milk or sour milk' was replaced with 'skimmed milk (less than 0.3% fat)'.

The PI of the research was present when students answered the questions to provide examples of foods and help students calculate their portion intake. SurveyMonkey® software was used to administer the questionnaire online however the content and structure remained unchanged. The mean time for completing the questionnaire was 10 minutes. The administered IDQ questionnaire is presented in Appendix I.D.

3.6.4 Physical activity

Physical activity is a core determinant of weight management along with dietary behaviour in university students (Willet, 2012). Physical activity has many dimensions related to its type, intensity, duration and frequency (Willet, 2012). Broad domains of physical activity include occupational, transportation, household and leisure-time activity (U.S. Department of Health and Human Services, 1996). According to the U.S. Department of Health and Human Services (1996), 'exercise' is a subset of leisure-time physical activity which is planned or structured, includes repetitive body movements and aims to improve or maintain physical fitness. Intensity of physical activity can be classified to light, moderate or vigorous based on the effort needed to undertake the exercise. Intensity is numerically estimated and expressed in Metabolic Equivalent Tasks (METs), where MET is a multiple of resting metabolic rate (Jetté et al., 1990). One

MET is the amount of oxygen consumed while sitting at rest and equals to 3.5 ml oxygen per kilogram of body weight per minute (Jetté et al., 1990). In general, less than 3 METs is regarded as light (e.g. casual walking), 3 to 6 METs as moderate (brisk walking) and more than 6 METs as vigorous intensity activity (e.g. running) (Ainsworth et al., 2000).

Questionnaires as well as diaries and logs are frequently self-administered methods used to estimate physical activity (Willet, 2012). Although these methods are subject to recall bias, they are easy, quick and inexpensive to quantitatively assess physical activity in large populations (Dale et al., 2002). Physical activity can be more accurately measured with the use of technology such as accelerometers, heart rate monitors, indirect calorimetry and the technique of double labelled water, but these are expensive and time-consuming methods and not accessible in the field (Willet, 2012). The International Physical Activity Questionnaire (IPAQ) developed by Craig et al. (2003), is a questionnaire to assess physical activity and has been standardised in many countries (http://www.ipaq.ki.se/). The questionnaire has a long and a short version; the long version includes questions on frequency and duration of a variety of activities related to occupational, transportation, household and leisure-time activities; the short version includes questions about the frequency and duration of all vigorous and moderate-intensity activities as well as walking (Craig et al., 2003). Data from the IPAQ are expressed in weekly METs per minute, where walking corresponds to 3.3 METs, moderate-intensity activities to 4.0 METs and vigorous-intensity activities to 8.0 METs. Both versions of the questionnaire also address daily sitting time.

In this research project, the IPAQ short form (IPAQ-SF) was chosen to assess physical activity behaviour in university students. IPAQ-SF was preferred, assuming students would undertake mainly exercise during their leisure-time (doing sports, join the gym) rather than work-related or household activities. Additionally, the IPAQ-SF has been used in similar studies among university students (Franko et al., 2008; Kattelmann et al., 2014), it is a cost-effective and quick self-administering tool and computes METs, which is a measure of physical activity without taking into account body weight (Willet, 2012). Based on the total score of weekly METs per minute, IPAQ-SF also classifies individuals into different levels (low, moderate, high) of physical activity (www.ipaq.ki.se).

3.6.4.1 Validation of the IPAQ-SF questionnaire

In general, the IPAQ has a good test-retest reliability (r=0.8) and validity which has been tested in 12 nations (Craig et al., 2003). The validity of the IPAQ-SF has been tested in 23 studies using various population and the results have been summarised in the systematic review undertaken by Lee et al. (2011). The review found a great variation among studies and in general, the questionnaire tended to overestimate the amount of physical activity compared to objective measures of activity. Dinger et al. (2006) validated the IPAQ-SF among college students (n=123) and compared the findings of the IPAQ-SF with accelerometers and pedometers. The study found a small-to-moderate correlation coefficient (ranging from 0.21 to 0.44) for total and sub-types of weekly physical activity indicating the IPAQ-SF is a weak but acceptable tool to use in research. These findings are similar to other self-reported physical activity questionnaires (Lee et al., 2011). To increase the reliability and validity of physical activity measures in this research project, pedometers were provided to the participants for one week after completing the IPAQ-SF. However, most students lost or reported to have forgotten to wear the pedometer, resulting in great amounts of missing or inaccurate data. Therefore, at the end the study, the PI decided to exclude the pedometer data. A pilot study was undertaken with five students to assess the administration and feasibility of the IPAQ-SF. The students did not face difficulties when completing the IPAQ-SF and no adaptations were needed. SurveyMonkey® was used to administer the questionnaire online without changes to its content. The mean time for completing the questionnaire was 10 minutes. The administered IPAQ-SF is presented in Appendix I.E.

3.6.5 Health indicators

Factors that affect nutrition and physical activity such as age, gender, ethnic group, field of study, residence status, perceived health rating, current dieting practices, smoking status and acquired nutrition qualifications (Deliens et al., 2014; Deliens et al., 2015a) were collected at baseline as part of the GNKQ-R. Metabolic risk variables including body composition parameters, blood pressure and fasting blood glucose, were also assessed before and after the implementation of the e-programme in the RCT. All measurements were taken by the PI and took place in two private laboratories at the universities. The same devices were used in both labs. The lab technician of each university calibrated the electronic devices prior to the research project, following the instructions provided in the devices' manuals.

Body mass (weight) was measured to the nearest 0.1 kg using an electronic scale (Seca) (Figure 3.3. item #1) and stature (height) to the nearest 0.1 cm using a transportable stadiometer (Seca, Chino, CA) (Figure 3.3. item #2). Students were asked to arrive in the morning, urinate before the measurement and remove their shoes, empty their pockets and remove heavy clothing. Body weight and height was self-reported in the cross-sectional study. Although self-reported weight and height tend to be lower than clinical measures, studies have shown that errors from self-reported measures have a small effect on associations observed in epidemiological studies and are still important information (Willet, 2012).

Body Mass Index (kg/m^2) was calculated based on mass (kg) and stature (m), and participants were classified according to their BMI percentiles as underweight (<18.5 kg/m^2), healthy weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) or obese (≥30.0 kg/m^2) (World Health Organization, 2018). As BMI might be misleading for particular groups of people, including those with increased muscle mass (Nuttall, 2015), body fat content (expressed as percentage of total body weight, %) was also measured to increase accuracy of measurements.

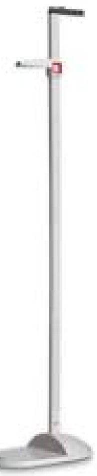
Body fat (%) was assessed by bioelectrical impedance (BIA) using a segmental body composition analyser (TANITA BC-418) (Figure 3.3. item #3). Fat content represents the percentage of total body mass that is fat while fat-free mass (kg) includes muscle, bone, tissue, water and all other fat-free mass in the body. In BIA, an electric current is going through the body tissues and fat-free mass is calculated based on the principle that lean mass is a conductor of electricity due to its ion and water content in contrary to body fat tissue (Willet, 2012). For those aged 20-39 years with a healthy BMI, values for normal body fat range between 21% and 33% for females and 8% to 20% for males (Gallagher, et al., 2000). Participants were advised to arrive fasted in the morning (fasting period >8 hours), urinate before the measurement and avoid intense exercise and alcohol intake the previous day. Although more accurate methods to measure body fat exist, such as densitometry or hydrostatic plethysmography, they are very expensive (Willet, 2012). As body fat was not the primary outcome in this research, the use of a segmental body composition analyser was preferred as a safe, quick, inexpensive and accurate method.

Waist circumference (WC) was measured as an index of central adiposity. The measurement was taken on bare skin when possible, at the midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the mid-axillary line. A standard flexible measuring tape (Seca) was used (Figure 3.3. item #4) and record was rounded to the nearest 0.1 cm following a normal exhalation (World Health Organization, 2008). A WC >94 cm for men and >80 cm for women indicated an increased metabolic risk. Again, more accurate methods (e.g. DEXA), exist to measure intrabdominal and subcutaneous central fat but easiness and low financial resources excluded their use in this research.

Systolic and diastolic blood pressure (mmHg) was measured using an electronic sphygmomanometer (Omron M4) (Figure 3.3. item #5). Participants were asked to arrive in the morning and avoid exercising, caffeine intake and smoking before measurement. They were asked to sit on a comfort chair with their back straight and supported, feet flat on the floor and legs uncrossed. Blood pressure was measured twice, in a sitting position with the arm placed at the level of the heart and free of tight clothes, after resting for a couple of minutes prior to and between the measurements (Whelton et al., 2018). The average of two readings for systolic and diastolic blood pressure were considered as the final values. Following the American College of Cardiology and the American Heart Association updated Guidelines on blood pressure, levels below 120/80 mmHg were classified as normal (Whelton et al., 2018).

Blood glucose (mmol/l) was measured using a portable handheld blood glucose analyser (Accu-Chek Aviva) from capillary blood by fingerpick technique (Figure 3.3. item #6). Capillary sampling from a finger is a safe and quick procedure requiring small quantities of blood. Participants were asked to arrive in the morning, fasted and blood glucose was compared against normative values (4.0-5.4 mmol/l) (National Institute for Health and Care Excellence, 2017). A lancet was used to puncture the skin of the finger and the first blood drop was wiped away by alcohol tissues (World Health Organization, 2010). The following blood drop was collected and inserted to the strip of the glucose analyser. The strip was entered into the designated notch of the analyser (using the side without the blood) and the measurement appeared five seconds later on the screen of the device. A firm pressure was applied on the pricked finger to stop the bleeding. Strips and lancets were disposed immediately to sharp bins and wipe tissues to clinical waste bins. All safety precautions (e.g. hygiene rules, use of non-sterile gloves) were followed. The procedure followed for capillary sample is illustrated in Figure 3.4.

1. Electronic scale



2. Stadiometer

3. Body composition analyser

4. Measuring tape

5. Electronic sphygmomanometer

6. Blood glucose analyser

Figure 3. 3. Instruments used to assess anthropometric and metabolic risk variables

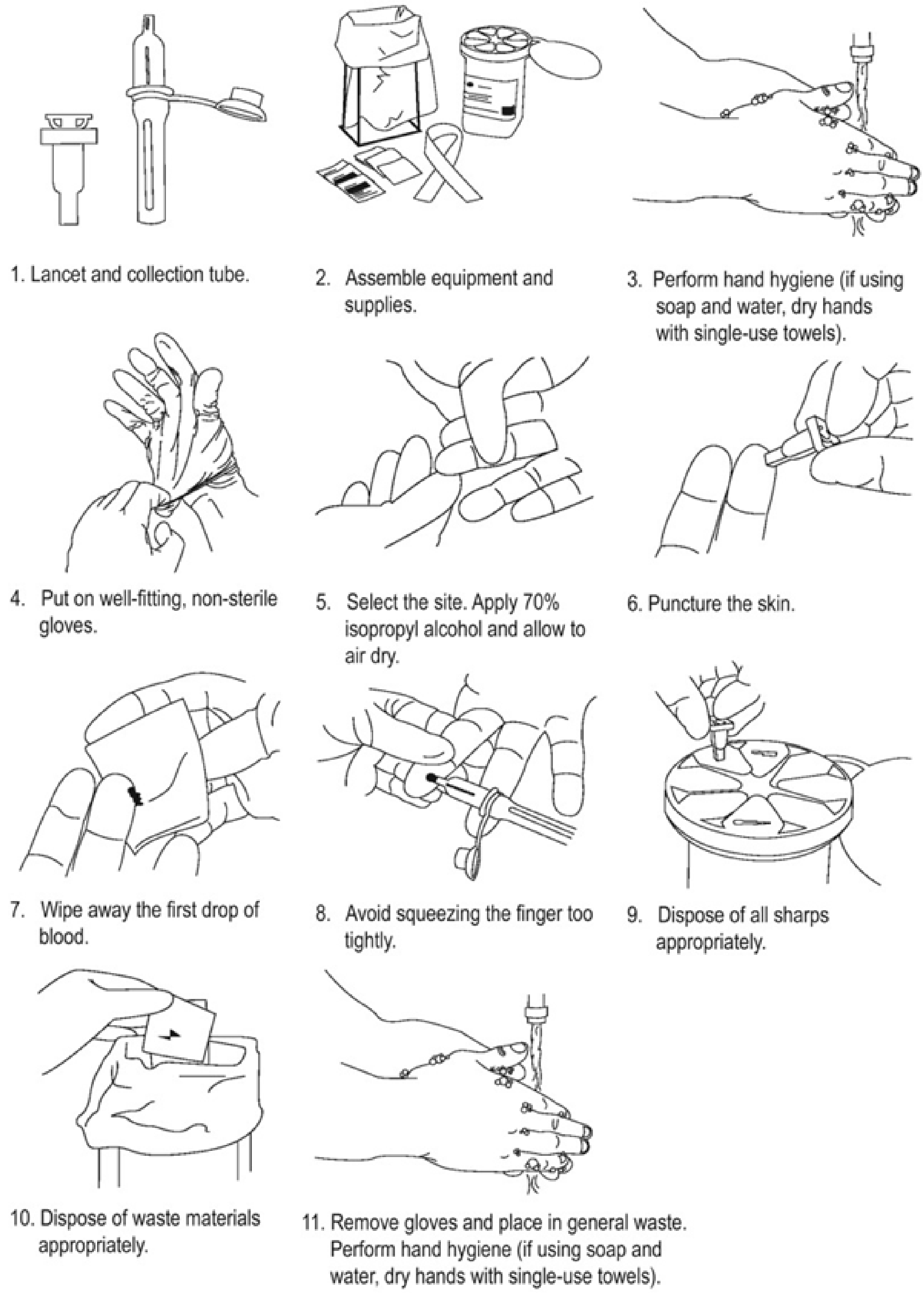


Figure 3. 4. Capillary blood sampling

Figure sourced from World Health Organization (2010)

3.7 Data processing and analysis

All data collected electronically (through SurveyMonkey®) or in the laboratory were entered into excel spreadsheets for data cleaning and analysis. The datasheets were inspected to detect incomplete, incorrect or inaccurate inputs. They were also tested for identical double records by comparing the following socio-demographic variables: sex, age, university, faculty, living arrangement, ethnicity and smoking status. Values on closed-ended questions such as body weight and height were inspected for answers with incorrect units of measure and corrected, if possible, otherwise deleted. Datasheets were also inspected for outliers which were handled according to questionnaires' guidelines, otherwise excluded from the analysis. Any record with no consent was deleted. The rate of missing data across the datasets was also calculated. In the cross-sectional study, the Little's Missing Completely At Random (MCAR) test was performed to investigate whether the data was randomly missing or not (Little, 1998). The test failed to reject the null hypothesis, meaning that data was not randomly missing. Therefore, in this study, the highest number of cases in each variable was used and no imputation or other method was performed to account for the missing data.

In the RCT, an intention to treat (ITT) analysis was performed, meaning that participants who entered the study but dropped out were still included in the analysis, assuming their baseline data did not change throughout the intervention (Armijo-Olivo et al., 2009). Many researchers regard ITT analysis superior compared to simple protocol analysis, in particular, when trials are implemented in real-life and no deviations from protocol can be assured. ITT analysis uses all sets of data without considering withdrawals and non-adherents and therefore tends to de-emphasise the impact of the intervention on outcomes of interest. Normality tests (Shapiro-Wilks or Kolmogorov-

Smirnov test) and plots (Q-Q probability or cumulative frequency plots) were used to determine whether the data in each study followed a normal distribution (Ghasemi & Zahediasl, 2012). When the null hypothesis of the test is rejected, the data tested did not follow a normal distribution and non-parametric tests were applied in the analysis.

Nutrition knowledge, diet quality and physical activity were the main outcomes of interest in this research project. Other factors (e.g. anthropometry, socio-demographic) which may affect the main outcomes were also assessed. As a result, a set of variables was assessed and analysed based on the objectives of each study. Some of these variables were numeric, such as age or diet quality score and some were categorical such as gender and ethnicity. There were also variables that could be processed and analysed both as numeric and categorical. For instance, BMI could be used in the analysis as a continuous variable but also as a categorical variable (underweight/normal/overweight) based on the cut-off points. Table 3.2 summarises the variables assessed in each study and the type of variable used in data processing and analysis, i.e. variables that were processed and analysed as numeric, categorical or both, as well as their cut-off point or definitions in this research (when applicable).

IBM SPSS Statistics 24 software was used for the analysis of data in both studies (cross-sectional and RCT) of the research project and the book by Field (2013) was used as a guidance for the application of the appropriate statistical tests and analyses. As each study followed a different design based on its objectives, the statistical tests of each study are described in detail in Chapters 5 and 6. In general, descriptive statistics were performed to calculate the scores of nutrition knowledge sections and logistic regression to identify predictors of 'good nutrition knowledge' in the cross-sectional study. In the RCT, Generalised Estimation Equation (GEE) models were applied to investigate for significant differences in outcomes within and between the two groups of study (control versus intervention) across time (i.e. before and after the intervention) accounting for potential confounders. The significance level was set at 0.05 for all tests.

Table 3. 2 Variables used in each study of the thesis, their assessment methods, types and cut-off points/definitions

Variables used in the research	Assessment method	Studies assessed the variable and time of assessment	Type of variable	Cut-off points/definition
Nutrition Knowledge				
Knowledge of dietary recommendations	Questionnaire (GNKQ-R)	CSS[1] (assessed one-off) RCT (assessed pre-and post-intervention)	Numeric (score)	A higher score indicated higher knowledge (maximum score 18).
Knowledge of sources of nutrients		CSS (assessed one-off) RCT (assessed pre-and post-intervention)	Numeric (score)	A higher score indicated higher knowledge (maximum score 36).
Knowledge of healthy food choices		CSS (assessed one-off) RCT (assessed pre-and post-intervention)	Numeric (score)	A higher score indicated higher knowledge (maximum score 13).
Knowledge of diet-disease relationships		CSS (assessed one-off) RCT assessed pre-and post-intervention	Numeric (score)	A higher score indicated higher knowledge (maximum score 21).
Overall Knowledge		CSS (assessed one-off) RCT (assessed pre-and post-intervention)	Numeric (score) & Categorical (poor/good)	A higher score indicated higher knowledge (maximum score 88). 'Good Knowledge' defined as having a score equal or higher than the 75th percentile cut-off point of the mean overall GNKQ score of the sample population of each study.
Dietary Intake				
Index of Diet quality	Questionnaire (IDQ)	CSS (assessed one-off) RCT (assessed pre- and post-intervention)	Numeric (score) Numeric (score)	A higher score indicated higher diet quality (maximum score 88). 'Good diet quality' defined as having a score ≥10.

Variables used in the research	Assessment method	Studies assessed the variable and time of assessment	Type of variable	Cut-off points/definition
Physical Activity				
Physical activity	Questionnaire (IPAQ-SF)	RCT (assessed pre- and post-intervention)	Categorical (Low/ Moderate/ High)	Categories of physical activity: **High**: ≥ 3 days/week of vigorous activity accumulating ≥ 1500 MET-min/week OR ≥ 7 days of any type of exercise. accumulating ≥ 3000 MET-min/week. **Moderate**: ≥ 3 days/week of vigorous activity ≥ 20 min per day OR ≥ 5 days of moderate activity and/or walking ≥ 30 min per day OR ≥ 5 days/week of any type of activity accumulating ≥ 600 MET-min/week. **Low**: Activity that is not enough to meet the other two categories.
Sitting time	Questionnaire (IPAQ-SF)	RCT (assessed pre- and post-intervention)	Numeric (minutes per day)	No recommendation available.
Health indicators				
BMI (body weight/ height^2) (kg/m^2)	Self-reported (CCS) Assessed by PI (RCT)	CSS (assessed one-off) RCT (assessed pre-and post-intervention)	Numeric (kg/m^2) & Categorical (underweight/ normal/ overweight/ obese)	Categories of BMI: **Underweight**: <18.5 **Normal**: 18.5-24.9 **Overweight**: 25.0-29.9 **Obese**: ≥30.0
Body fat content	Assessed by PI using bioelectrical impedance	RCT (assessed pre-and post-intervention)	Numeric (% of total body weight) & Categorical (normal/ high)	A **normal** body fat (%) content is 8-20% in males and 21-33% in females aged 20-39 years.
BMI/body fat index	Created from variables BMI and Body Fat (BF)		Categorical (Healthy/ Unhealthy)	The **Healthy** BMI/BF index included those with a healthy BMI and healthy BF (%) or high BMI and healthy BF (%) for their gender and age. The **Unhealthy** BMI/BF index included those with a high BMI and high BF (%) or normal BMI and high BF (%) for their gender and age.

Variables used in the research	Assessment method	Studies assessed the variable and time of assessment	Type of variable	Cut-off points/definition
Waist circumference	Assessed by PI using a measuring tape	RCT (assessed pre-and post-intervention)	Numeric (cm) & Categorical (low risk/ high risk)	**High** disease **risk** is defined as having a waist circumference: > 94 cm for males and > 80 cm for females.
Systolic (SSB) and diastolic (DBP) blood pressure	Assessed by PI using electronic sphygmomanometer	RCT (assessed pre-and post-intervention)	Numeric (mmHg) & Categorical (normal/ elevated including stage I & II Hypertension)	Categories of blood pressure: **Normal**: <120/80 **Elevated**: >120/80 & <130/80 **Stage I Hypertension**: 130-139 (SPB) & 80-89 (DPB) **Stage II Hypertension**: ≥140/90.
Fasting blood glucose	Assessed by PI via collection of capillary blood by fingerpicking and handheld blood glucose meter	RCT (assessed pre-and post-intervention)	Numeric (mmol/L)	Normal range for fasted blood glucose: 4.0 to 5.4 mmol/L.
Socio-demographic				
Age	All socio-demographic variables were assessed as part of the GNKQ-R questionnaire	CSS (assessed one-off) RCT (assessed at baseline)	Numeric (years)	
Gender			Categorical (Male/ Female)	

Variables used in the research	Assessment method	Studies assessed the variable and time of assessment	Type of variable	Cut-off points/definition
Ethnic origin			Categorical (merged to White/ Black/ Asian/ Mixed)	The **White** category included the White British, White Irish or other White background. The **Black** category included the British, Black Caribbean, Black African or other Black background. The **Asian** category included the Indian, Pakistani, Bangladeshi, Chinese or other Asian background. The **Mixed** category included the White and Black Caribbean, White and Black African, White and Asian or other mixed background.
Living arrangement	All socio-demographic variables were assessed as part of the GNKQ-R questionnaire	CSS (assessed one-off) RCT (assessed at baseline)	Categorical (living with parents, carer, family/ sharing a house or flat/ student accommodation/ alone in a house or flat)	
Faculty of study			Categorical (Health Social Care and Education/ Science, Engineering and Computing/ Arts and Social Sciences/ Business and Law/ Art, Design and Architecture/ Medicine or Biomedical Science)	
Studying status		CSS (assessed one-off) RCT (assessed at baseline)	Categorical (undergraduate/ postgraduate)	

Variables used in the research	Assessment method	Studies assessed the variable and time of assessment	Type of variable	Cut-off points/definition
Having a nutrition qualification			Categorical (yes/no)	
Perceived health rating		CSS (assessed one-off)	Categorical (poor/ fair/ good/ very good/ excellent)	
On a special diet			Categorical (yes/ no)	
Being a smoker		CSS (assessed one-off)	Categorical (yes/ no)	
Field of study	Created from variables Faculty and Nutrition Qualification.	CSS (assessed one-off) RCT (assessed at baseline)	Categorical (Healthcare and non-Healthcare)	The **Healthcare** field of study category included students from the Faculty of Health, Social Care and Education and the Medicine/Biomedical Sciences and those from other Faculties with a nutrition qualification. All other students were included in the **Non-Healthcare** field of study.

[1] CSS: Cross sectional study

3.8 Ethical considerations

3.8.1 Participant information sheets and informed consent

The participant information sheets and consent forms were given to potential participants prior to their engagement in the research as described earlier. The participant information sheets provided information about the aims and procedures of the study, the possible benefits and risks of taking part, and the methods of handling the information of participants. It also included contact details of the PI and primary academic supervisor in case potential participants and participants wanted to ask questions or make complaints. In the cross-sectional study, participants had to declare consent by selecting the appropriate boxes on the online questionnaire in order to enter the questionnaire of the study. If consent was not given, participants were unable to proceed with the online questionnaire. In the RCT, the PI met the potential participants in person and asked them to read the participant information sheet again and sign the consent form before entering the study. The voluntary nature and anonymity of participating was emphasised on all forms. Students had the right to withdraw from the research at any time without given a reason. They also had the right to decide which questions to answer and which measuring procedure to participate with.

3.8.2 Handling potential risks

All measures were taken by the PI in the laboratory facilities at both universities following safety rules and supervised by the technicians of the two labs. There was a potential risk while undertaking the measurements to find abnormal health indicators that require healthcare attention, e.g., a high level of fasting blood glucose or a high blood pressure. In such cases, the PI would immediately discuss the situation with the supervisors and a decision would be reached regarding the best way of breaking the bad news to the participants and directing them to appropriate health care provision. The participation in the study for the affected individual would be terminated in line with the inclusion/exclusion criteria. There was also a low possibility that some measures might cause minor physical and emotional distress. Measurement of waist circumference required some bodily contact, which might make some participants feel uncomfortable. In this case, participants could ask for a third person to be present or had the choice to undertake the measurements themselves under the PI's guidance. In addition, blood glucose was measured using finger pricking. If participants felt finger pricking upsetting, the procedure would stop, and participants would be given a break, or they had the choice not to participate in this measurement procedure. The aforementioned potential risks and benefits were clearly stated in the participant information sheet and the contact details of the academic supervisor were available in case students wished to make a complaint.

3.8.3 Data handling

All data was handled and protected according to the Data Protection Act (2009). After enrolment in the RCT, each participant was given a code number using a unique 3-digit number that was unidentifiable by all outcome assessors. Only the PI and academic supervisors of the study had access to the raw data and anonymity was maintained at all times using the ID numbers instead of personal details. Data extracted from the questionnaires and laboratory measures was stored in encrypted files, in a password protected computer located in the PI's office. The data was backed up on a daily basis to the university's secure server. Paper-based data was stored in locked filing cabinets in the PI's office and only the PI and the primary academic supervisor of the study had keys to the locker. Data will be stored for 10 years from the end of the research, following University ethics guidelines. At the end of the retention period, data will be reviewed and assessed regarding their value. If data considered of long-term value, it will continue to be stored in the KU archive dataset with a restricted access to the supervisors of the study. Data considered of no longer value will be destroyed from all sources by the PI (if still present in the University) or by the supervisors of the study, provided support by the IT staff of the Faculty on erasing digital data from all electronic sources. Anonymous data was and will be published for scientific purposes. Participants will not be identifiable in any of the reporting of the findings. Phone calls to participants were made using safe landlines from SGUL and KU and a new email address was created and used to contact participants and to send materials and information related to the study. All data from the email address will be erased five years after the completion of the research project with IT support of KU.

3.8.4 Funding sources

The PI received a 3-year studentship from KU to undertake her doctoral research. The studentship was for living purposes and did not financially support the research project. Therefore, the PI has no conflict of interest to declare. In the cross-sectional study no financial incentives were given to participants who completed the online questionnaire. In the RCT, a £10 Amazon voucher was given to participants who completed the study. The incentive was introduced after many students made contact prior to the study to ask whether there was a financial reward if agreeing to participate in the study. The vouchers were paid from money collected through the fundraising platform of KU (KUBacker). A short description and a video of the study was uploaded at the platform and then disseminated to alumni and social media and raised in total

£514 (https://kubacker.hubbub.net/p/unismarteating/). No other funding was used for the purposes of this research.

3.8.5 Ethical Approval

Applications for each study were submitted separately for consideration to the Faculty of Health, Social Care and Education Research Committee (FREC). The FREC revised the applications, asked for clarifications and amendments for both studies. The requested changes were made and the FREC gave favourable opinion for both studies.

Chapter 4. Interventions targeting dietary, physical activity and weight-related outcomes among university students- a systematic review of systematic reviews (Overview)

4.1 Overview of the chapter

Improving dietary behaviour in early adulthood can prevent weight gain and the incidence of chronic diseases in later adulthood as reported in the **Literature Review** (Chapter 2, section 2.5.4). As a result, many interventions have been implemented within universities to promote health in students. The chapter aims to identify the different types of interventions implemented among university students targeting dietary, physical activity and weight-related outcomes and provide an estimate of their overall effect. To achieve that, a systematic review of systematic reviews (overview) was undertaken following a specific methodology. A brief description of the reviews identified from the overview process as well as the assessment of their methodological quality is presented. The individual studies of the identified reviews were put together in order to identify the different types of intervention by grouping interventions with similar components as well as identify and group the similar outcomes of studies. The overall effect of each type of intervention was assessed to explore whether a specific type of intervention is more beneficial compared to others. The findings of the overview are summarised in tables and comparisons of findings with other reviews and their future implications are discussed.

4.2 Introduction

Many interventions aimed at improving lifestyle habits of university students have been implemented and there exists a plethora of studies, summarised in systematic reviews. An additional issue when synthesising studies aimed at improving health of university students, is that the outcomes and interventions of these studies vary considerably, making the synthesis of results challenging. The main outcomes with regards to diet are food intakes (Ha & Caine-Bish, 2009), sales of foods (Roy et al., 2016) or cognitive variables reflecting dietary behaviour (e.g. self-efficacy) (Poddar et al., 2010). Physical activity interventions vary in terms of the types of exercise prescribed (aerobic, flexibility, resistance) and variations in intensity (light, moderate, vigorous) (Claxton & Wells, 2009) and outcomes are often cognitive, reflecting exercise intentions and self-efficacy towards exercise behaviour (Huang et al., 2009). Weight gain and changes in body composition are also outcomes of poor dietary habits and low activity levels reported in some studies (You et al., 2009). A variety of interventions have been used with examples including online programmes (Brown et al., 2011), in-class courses (Ha et al., 2009), education delivered by peers (Boyle et al., 2011) and nutrition labelling on food items available in university canteens (Roy et al., 2016).

4.3 Rationale of undertaking an overview

In recent years, the plethora of existing interventions has resulted in undertaking more than one systematic review investigating the same research topic (Hunt et al, 2018). As a result, policy makers and researchers are sometimes overwhelmed by the overload of information summarised in a number of reviews with apparently similar eligibility criteria, making the process of evidence-based decision making more challenging (Ioannidis, 2016). When there has been more than one attempt to synthesise the existing evidence, the ideal starting point is to undertake a systematic review of reviews (Smith et al., 2011). According to the Cochrane Handbook, undertaking an overview of systematic reviews allows the synthesis of data at different levels, such as when there have been different types of interventions, different populations or different outcomes reported for the same topic (Becker & Oxman, 2009). This allows the researcher to gain a comprehensive knowledge on a topic and facilitates practitioners and policy makers towards the process of decision-making by summarising, appraising and pooling together the existing evidence (Hunt et al., 2018).

Besides the advantages, there are also challenges when undertaking an overview (Pollock et al., 2016). Since this is a new approach, a well-established methodology of undertaking an overview of systematic reviews is lacking (Pollock et al., 2016). The way authors conduct a systematic review of the literature in terms of framing the question, search criteria, outcomes of interest and methods of assessing and analysing the results might lead to heterogeneity and difficulties in comparing and bringing together the findings of apparently similar systematic reviews (Pollock et al, 2017). Other challenges include the overlapping of studies that appear in more than one reviews, the date limitations that might lead to missing data as well as the methods the reviewers use to report their findings such as the method used to report effectiveness of studies when a meta-analysis is not feasible (Pollock et al., 2017). Another challenge is the methodological quality of reviews as only 3% are recognised as being of good quality (Ioannidis, 2016). However, assessing the quality of reviews by applying established criteria (e.g. AMSTAR) can counterpart this limitation.

For the purposes of this research project, the PI identified that more than one attempt has been made to synthesise studies aiming to improve health-related outcomes in university students. Considering the variation of interventions and outcomes reported by studies, conducting an overview of systematic reviews was an appropriate method to explore the different types of interventions that benefit dietary, physical activity and weight-related outcomes and identify gaps in research knowledge and practice. It would also elaborate on the overall effect of each type of intervention in order to design and develop an interventional study to improve dietary and physical activity outcomes in university students as part of this research project.

4.4 Aim and objectives of the overview

The overall aim of the overview was to systematically bring together, appraise and synthesise reviews including interventions targeting dietary, physical activity and weight-related outcomes in university students. In particular, the objectives of this overview were to a) identify systematic reviews and meta-analyses of studies aiming to improve dietary, physical activity or weight-related outcomes in university students, b) assess their methodological quality, c) identify the different types of interventions used and outcomes assessed and d) estimate the overall effect of the different types of interventions (**objective 1 of the thesis**).

4.5 Methods

A systematic review of systematic reviews (overview) was undertaken following the methods suggested by Smith et al. (2011) and guided by the PRISMA statement (Liberati et al., 2009). A protocol for the overview was not available.

4.5.1 Eligibility criteria of studies

Systematic reviews of trials evaluating the effect of interventions to improve dietary intake, physical activity or weight-related variables among university students were considered for inclusion. Reviews with both meta-analyses and narrative combination of results were included. The acronym PICOS (Population, Intervention, Comparison, Outcomes and Study Design) was used to develop a focused question and establish inclusion and exclusion criteria for this overview (Uman, 2011). The PICOS criteria are listed in Table 4.1.

Table 4. 1 The PICOS criteria for inclusion of reviews

Acronym	Category	Inclusion and exclusion criteria
P	Population	University or college students who are in good health. Reviews focusing on a sub-population of university students, such as athletes, or overweight/obese students or students with eating disorders were excluded. Reviews targeting young people in general, with less than 70% of their included studies implemented on university students, were excluded.
I	Intervention	Reviews including: Any type of dietary/nutrition, physical activity or combined intervention aiming to improve dietary, activity or weight-related outcomes implemented in a university environment. Any type of weight gain prevention intervention implemented in a university environment. Interventions targeting alcohol or aiming to treat a disease/clinical condition (e.g. obesity) were excluded.
C	Comparison	Reviews with trials with no comparison group or a comparison group that received no intervention or a comparison group that received a different type of intervention were included.
O	Outcomes	Reviews targeting: Dietary or nutrition related outcomes including dietary intake, food habits, diet quality, nutrition knowledge/awareness/attitudes, cooking skills, food selection/purchase, behavioural and cognitive skills towards dietary practices such as self-efficacy and self-regulation. Physical activity or exercise related outcomes including fitness, intensity (moderate, vigorous) and frequency (time/days spent), number of daily steps, physical activity knowledge/attitudes as well as cognitive and behavioural skills such as stage of change, self-efficacy and goal setting towards exercise. Anthropometric and clinical parameters including body weight, BMI, body composition and metabolic risk indicators. Weight gain prevention, prevention of chronic diseases and improvement of overall quality of life.
S	Study types	Reviews conducted in a systematic way or meta-analyses including trials were eligible. Reviews including only descriptive/cross-sectional studies or where less than 70% of their studies involved a population other than university students were excluded.

4.5.2 Search methods for identification of reviews

The electronic databases Pubmed, Medical Literature Analysis and Retrieval System Online (MEDLINE) OvidSP, Cochrane Database of Systematic Reviews (The Cochrane Library) and Google Scholar were searched for systematic reviews from their inception dates until 7th June 2016 and updated in 19th March 2018. The reference lists of included reviews were searched and reviews identified from the 'similar articles' feature in Pubmed were assessed against the inclusion criteria. In addition, the database WorldCat and the libraries of two universities for dissertations, conference proceedings and press articles were searched. The authors of the included reviews were contacted to enquire about their knowledge of other relevant reviews in the field.

Keywords and Medical Subject Heading [MeSH] terms such as: intervention, nutrition, diet, food habits, physical activity, exercise and university were used to run the search in each database. Searching was limited to 'systematic reviews' or 'reviews' and no language limitation was applied (Appendix II.A).

4.5.3 Selection and extraction of reviews

Titles and abstracts were examined on the screen against the inclusion and exclusion criteria and relevant articles were retrieved based on their title or abstract. After removing duplicates and excluding irrelevant reviews by abstract, the eligibility of the full text articles was assessed.

4.5.4 Synthesis of findings

4.5.4.1 Summary of characteristics of identified reviews

The following descriptive data was extracted for each identified review: first author and year of publication, main objective of the review, searching methodology (number and time period of databases searched and search limitations), characteristics of individual studies (number of studies and study design, total number of participants, quality rating of studies based on reviewers' quality assessment), outcomes reported within studies, the approach used to synthesise/present the overall results of studies, number of studies reporting having a positive impact on outcomes (as stated by the authors of reviews) and authors' conclusions.

4.5.4.2 Methodological quality of reviews

Quality appraisal of the identified reviews was based on the AMSTAR 2 (A MeaSurement Tool to Assess systematic Reviews) criteria (Shea et al., 2017). The AMSTAR 2 tool is suitable for assessing methodological issues in reviews including both randomised and non-randomised healthcare interventions. It consists of the following 16 criteria: 1) the application of PICO, 2) existence of a pre-registered protocol, 3) explanation of study design selection, 4) search strategy, 5) study selection in duplicate, 6) data extraction in duplicate, 7) list and justification of excluded studies, 8) description of included studies, 9) assessment of risk of bias of studies, 10) reporting funding sources of studies, 11) conducting a meta-analysis (if applicable), 12) assessing the impact of risk of bias on the results of meta-analysis (if applicable), 13) interpreting findings considering potential risk of bias, 14) explaining heterogeneity of findings, 15) investigating publication bias (if applicable), and 16) declaring any conflict of interest.

Responses to the criteria are in the form of yes/ partial yes/ no. The AMSTAR 2 does not calculate a quality score and the overall appraisal is based on methodological weaknesses in critical domains. For the purposes of this overview, the methodological conduct of each included review was examined against the 16 criteria using the AMSTAR 2 checklist available online at https://amstar.ca/Amstar_Checklist.php. The online checklist calculates an overall judgement based on responses to each criterion, including 'high quality', 'moderate quality', 'low quality' and 'critically low quality'.

4.5.4.3 Synthesis of findings across reviews

In order to make an independent judgement of effectiveness of interventions, all studies included in each review were read and the following data was extracted.

i. Types of interventions of studies

The intervention described by studies were classified as a) environmental, if changes were made to the food service environment of universities (e.g. canteens, vending machines), b) face-to-face, if educators and learners were present at the same place during the intervention (e.g. in-class courses), c) e- interventions, if interventions were facilitated through the world wide web or with the use of technology and d) combined, if interventions included two or more of the above modes (environmental, face-to-face, e-intervention). Similar criteria to the above have been used before to group interventions (Deliens et al., 2016).

ii. Types of outcome measures of studies

The outcomes of studies were classified as a) dietary, including sales or purchases of foods/drinks/meals, intakes of foods/drinks/energy/nutrients, overall eating habits, diet quality as well as cognitive variables toward dietary behaviour, b) physical activity, including amount, length, frequency, type of exercise, fitness level, sedentary behaviour, as well as cognitive variables related to exercise behaviour and c) weight-related, including body composition measures (e.g. body weight, BMI, body fat, lean mass, WC, WHR), prevention of weight gain and related cognitive variables (e.g. body satisfaction).

iii. Data synthesis and overall effect of studies

The results of the original studies from each review were categorised according to intervention (environmental, face-to-face, e-interventions and combinations) and the similar outcomes were summarised. To estimate the overall effect of each type of intervention, we calculated the total number of outcomes suggesting a positive effect of each type of intervention (x) out of the total number of outcomes reported (y). A judgement of a positive effect was based on the direction of effect as many studies did not report the statistical significance or effect size of changes in outcomes. To determine the level of effectiveness (no effect, low, moderate, high), the following criteria were used:

• 0% of outcomes favour intervention = no effect;

• 1% to 33% of outcomes favour intervention = low effect;

• 34% to 66% of outcomes favour intervention = moderate effect;

• 67% to 100% outcomes favour intervention = high effect.

A similar decision rule has been used in other overviews (Flodgren et al., 2011). These results were then compared with the effects reported by individual reviews. The data was presented in a narrative synthesis as, due to the diversity of interventions identified and outcome measures reported, it was not possible to undertake a meta-analysis.

4.6 Results

The search strategy and selection process for eligible reviews is presented in Figure 4.1. Eight reviews were identified and included in the final analysis.

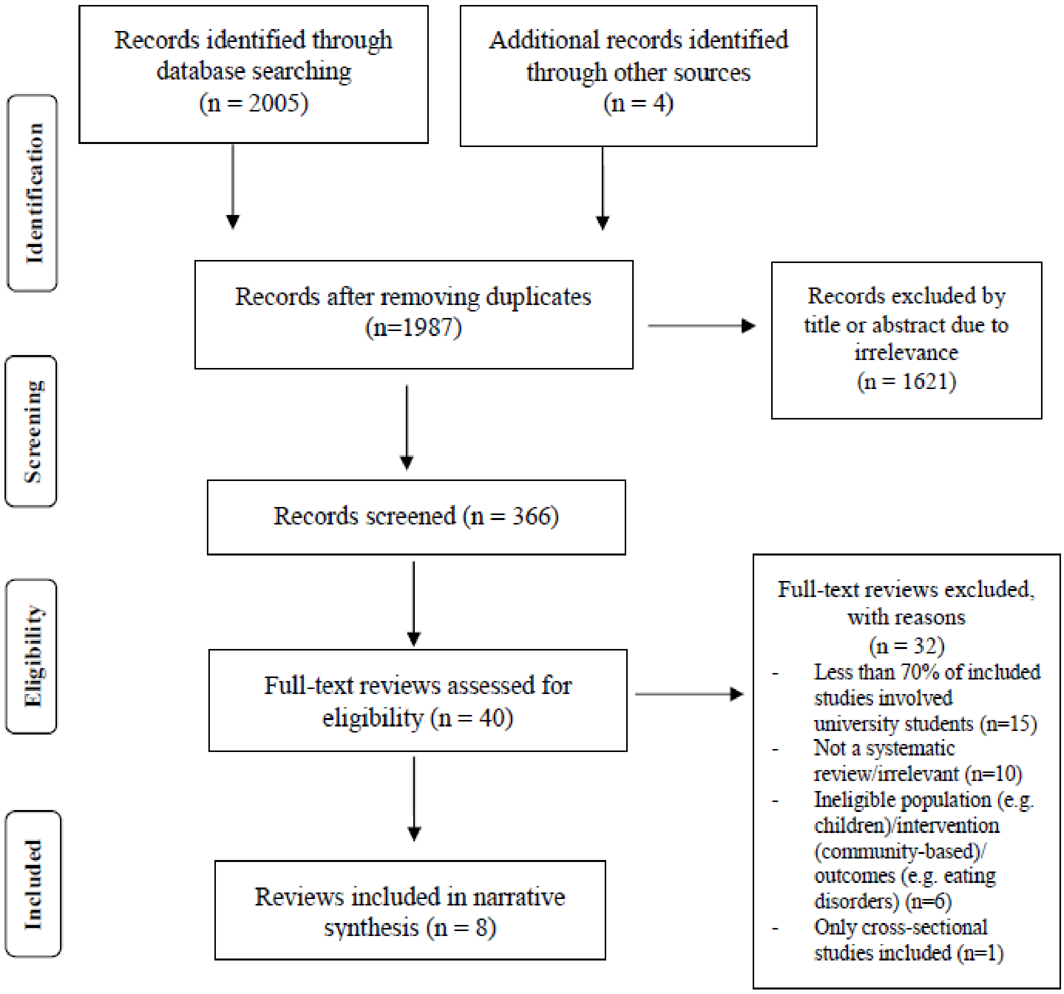


Figure 4. 1. PRISMA flow chart of databases search and selection of reviews.

The flow chart was sourced and adapted from Liberati et al. (2009)

4.6.1 Summary of characteristics of identified reviews

Two reviews (Roy et al., 2015; Christoph & An, 2018) focused on the impact of environmental interventions on food choices/purchases while the remainder investigated the impact of all types of intervention on diet (Lua & Wan, 2012; Kelly et al., 2013; Deliens et al., 2016), physical activity (Maselli et al., 2018), body composition (Laska et al., 2012) or all the above outcomes (Plotnikoff et al., 2015). Within reviews, the number of databases searched ranged from two (Kelly et al., 2013) to seven (Roy et al., 2015); two reviews limited their search to studies carried out in the US and/or Canada (Laska et al., 2012; Kelly et al., 2013). Among reviews that focused on environmental interventions, one identified 22 studies (Christoph & An, 2018) and one 15 studies (Roy et al., 2015). Among reviews targeting dietary behaviour, one identified 20 studies (Deliens et al., 2016), and two identified 14 studies (Lua & Wan, 2012; Kelly et al., 2013). One review targeted only physical activity and identified 27 studies (Maselli et al., 2018) and one included all types of outcomes and identified 41 studies of which 24 targeted diet, 29 physical activity and 12 weight-related outcomes (Plotnikoff et al., 2015). Finally, one review targeted weight gain prevention and identified 10 studies of which 8 were implemented among university students (Laska et al., 2012). Except two reviews (Deliens et al., 2016; Maselli et al., 2018), the rest identified a higher number of non-randomised than randomised controlled trials. With regards to the synthesis of results, four reviews presented their findings according to the different types of interventions (Laska et al., 2012; Kelly et al., 2013; Roy et al., 2015; Deliens et al., 2016), two according to the different outcomes reported (Plotnikoff et al., 2015; Christoph & An, 2018) and two (Lua & Wan, 2012; Maselli et al., 2018) did not use a specific method. A meta-analysis was undertaken only in two reviews (Plotnikoff et al., 2015; Christoph & An, 2018). The review by Laska et al. (2012) included a group of 28 studies targeting dietary and/or physical activity outcomes, which have been excluded from this analysis because the results were briefly mentioned in text and not presented in detail. A summary of the main characteristics of the identified reviews is presented in Table 4.2.

Table 4. 2. Main characteristics of the identified systematic reviews including interventions targeting improvements in dietary, physical activity and weight-related outcomes among university students.

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/ presentation of studies	Number of effective studies	
Christoph & An (2018)	To investigate the effect of nutrition label use on diet quality among university students.	4 databases were searched until 18th of May 2017 following the PRISMA guidelines. English language limitation applied. No country limitation applied.	n=22 (5 RCTs, 17 cohort or pre-post interventions)	≈ 27,100	Risk of bias: High: n=1; Average: n=19; Low: n=2. Assessment tool adapted from US National Heart Lung, and Blood Institute.	Dietary intake, diet quality and food choices	Studies were presented in tables and categorised by the type of dietary outcome to: Calories selected or consumed (n=13) Non-caloric measures (n=12) A meta-analysis was conducted showing fewer calories ordered/consumed among pre-post intervention using nutrition labels vs no labels [mean decreased of calories: 36.0, (95% CI: -60.2, -11.8), *P*=0.038, I^2=98.6] and among studies using contextual vs simple labels [mean decrease of calories: 66.9, (95% CI: -	Overall: 16/21 (76%). Assessing caloric selection/intake: 8/13 (62%) Assessing macronutrient selection/intake (diet quality): 9/12 (75%)	Nutrition labelling had a moderate but positive effect on dietary intake among university students.

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/ presentation of studies	Number of effective studies	
							86.7, -47.2), P=0.002, I^2=86.4]. A meta-analysis on RCTs showed no difference.		
Maselli et al. (2018)	To conduct a systematic review of interven-tions designed to improve physical activity among university students.	5 databases were searched until November 2016 following PRISMA guidelines. English language limitation applied. No country or other limitation applied.	n= 27 (24 RCTs, 3 non-RCTs)	11,376	Risk of bias: High: n=27; Average: n=7; Low: n=3. Assessment tool: Cochrane Collaboration Tool.	All physical activity outcomes.	Studies were presented in tables. A specific approach was not used. *A meta-analysis was not conducted.*	Overall: 16/27 (59%)	Personalised approaches and physical activity sessions seem promising parts of interventions. High risk of bias of studies limit the strength of conclusions with regards to effectiveness.
Deliens et al. (2016)	To provide an overview of interven-tions aiming to improve dietary	4 databases searched from January 2000 until December 2014 following the PRISMA	n=20 (12 RCTs, 1 non-RCT, 7 pre-post without	13,578	Risk of bias: High: n=1; Average:	Dietary habits, nutrient intakes, consumption of	Studies were presented in tables and categorised by the type of intervention to: Media/web-based interpersonal (n=6)	Overall: 13/20 (65%). According to type of intervention:	Nutrition education, with self-regulation, provided through technology and

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/ presentation of studies	Number of effective studies	
	intake among university students.	guidelines. English language limitation applied. No country limitations applied.	control group).		n=19. Assessment Tool: The Academy of Nutrition and Dietetics Quality Criteria.	foods/fluids/beverages and food or drinks sales/purchases.	Non-media based interpersonal (n=6) Combined interpersonal (n=1) Environmental (n=7). *A meta-analysis was not conducted.*	Web/ media-based: 5/6 (83%) Interpersonal: 2/6 (33%) Combined interpersonal: 1/1 (100%) Environmental: 5/7 (71%)	POP message strategies, may improve dietary intakes in short-term.
Roy et al. (2015)	To evaluate food environment interven-tions targeting young adults in university settings.	7 databases searched from 1998 until December 2014. The PRISMA guidelines were used. English-language limitation applied. No country limitation applied.	n=15 (3 RCTs, 2 pre-post interventions, 6 quasi-experimental and 4 cross-sectional).	≈3,753	Risk of bias: High: n=3; Average: n=7; Low: n=5. Assessment Tool: The Academy of Nutrition	Food choices, nutrition knowledge and/or food/drink sales.	Studies were presented in tables and categorised by the type of intervention to: Information about healthy foods through signage and labels (n=10) Availability of healthy foods through changing catering practices and portion sizes (n=3) Nutrition information with incentives (e.g. price reductions and	Overall: 13/15 (87%) According to type of intervention: Information through signage and labels: 8/10 (80%) Availability/ portion size (assessing dietary intakes): 3/3	Nutrition information, healthy options and decreased portion sizes as well as price reductions and increased availability of healthy options seem useful interventions to help improving dietary habits.

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/ presentation of studies	Number of effective studies	
					and Dietetics Quality Criteria.		availability of healthy foods) (n=2). *A meta-analysis was not conducted.*	(100%) Nutrition information with incentives: 2/2 (100%)	
Plotni-koff et al. (2015)	To examine effective-ness of interventions aimed at improving physical activity, diet, and/or weight-related behaviours amongst university students.	5 databases searched following PRISMA guidelines from January 1970 until April 2014. English language limitation applied. No country limitations applied.	n=41 (16 RCTs, 12 non-RCTs, 13 pre-post with no control group).	19,589	Risk of bias: High: n=8; Average: n=30; Low: n=4. Assessment Tool: The Academy of Nutrition and Dietetics Quality Criteria.	Dietary intakes, diet quality and related behavioural aspects (self-efficacy, etc.) Physical activity outcomes and related behavioural aspects (perceived barriers,	Studies were presented in tables and categorised based on the outcomes of interest to: Studies assessing dietary outcomes (n=24) Studies assessing physical activity outcomes (n=29) Studies assessing weight-related outcomes (n=12). A meta-analysis was conducted for total, moderate and vigorous activity (vs control conditions). A significantly higher level was found only for moderate physical	Overall: 34/41 (83%) Assessing dietary outcomes: 12/24 (50%) Assessing physical activity outcomes: 18/29 (62%) Assessing weight outcomes: 4/12 (33%)	Interventions including university courses with frequent face-to face contact and feedback to provide encouragement and support were effective at improving physical activity, dietary and weight-related outcomes.

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/ presentation of studies	Number of effective studies	
						etc.). Changes in body weight and body composition.	activity [Standardized Mean Difference: 0.18, (95% CI: 0.06, 0.30), P=0.005, I^2=0%].		
Kelly et al. (2013)	To review research literature evaluating nutrition and dietary interven-tions in university settings.	2 databases searched between January 2001 and June 2011 following the Institute of Medicine Guidelines. No English language limitation applied. Country limitation (US only) applied.	n=14 (6 RCTs, 1 quasi-experimental, 7 non-experimental).	≈2,691	N/A	Intakes of foods/drinks/nutrients, healthy eating rating, food sales and other aspects of dietary behaviour (cooking skills, goal setting, etc.).	Studies were presented in tables and categorised by the type of intervention to: - In-person (n=6), - Online (n=5), - Environmental (n=3). *A meta-analysis was not conducted.*	Overall: 11/14 (79%) According to type of intervention: In-person: 5/6 (83%) Online: 3/5 (60%) Environmental: 3/3 (100%)	In-person strategies including self-regulation, self-monitoring and goal setting were promising in improving students' dietary behaviour while environmental strategies could promote sales of healthy foods.

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/ presentation of studies	Number of effective studies	
Lua & Wan (2012)	To summarise studies on the effectiveness of nutrition educational interventions used by university students.	4 databases were searched from 1990 until 2011; no specific guidelines were mentioned. English language limitation applied. No country limitations applied.	n=14 (4 RCTs, 9 longitudinal, 1 cross-sectional).	1,536	N/A	Dietary intake, aspects of dietary behaviour (self-efficacy, etc.), body weight and body composition.	Studies were presented in tables. A specific approach was not used. *A meta-analysis was not conducted.*	Overall: 13/14 (93%)	Nutrition education with dietary supplement appeared the best methods for improving diet and promoting health.

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/ presentation of studies	Number of effective studies	
Laska et al. (2012)	To review studies examining weight gain prevention interventions among young adults.	5 databases searched from 1985 until July 2011 following a snowball strategy. No language limitation applied. Country limitations (US and Canada only) applied.	n=8 including university students (4 RCTs, 4 quasi-experimental)	877	N/A	Primary outcomes included changes in body weight and body composition.	Studies assessing weight-related outcomes were presented in tables and categorised by the type of intervention to: University courses (n=6) Other strategies (n=2). Studies addressing dietary intake (n=19), physical activity (n=8) or multiple health behaviours (n=1) were briefly mentioned in text. *A meta-analysis was not conducted.*	Overall (assessing weight variables): 6/8 (75%) According to type of intervention: University courses: 5/6 (83%) Other strategies: 1/2 (50%)	University course-based interventions showed some promising results in preventing weight gain among post-secondary students.

N/A: not applicable; POP: Point-of-Purchase; RCT: randomised controlled trials

4.6.2 Methodological quality of identified reviews

Methodological quality was moderate in five reviews (Roy et al., 2015; Plotnikoff et al., 2015; Deliens et al., 2016; Christoph & An, 2018; Maselli et al., 2018) and critically low in three reviews (Lua & Wan, 2012; Laska et al., 2012; Kelly et al., 2013). Reviews published more recently had higher methodological quality than earlier reviews. Key omissions of moderate quality reviews included failure to pre-register the protocol, justify the selection of study design and report sources of funding of included studies (Roy et al., 2015; Plotnikoff et al., 2015; Deliens et al., 2016; Christoph & An, 2018). Among low quality reviews, key omissions included all the previous plus failure to apply the PICO criteria (Lua & Wan, 2012; Laska et al., 2012; Kelly et al., 2013), assess the risk of bias of studies as well as report and justify the excluded studies (Lua & Wan, 2012; Laska et al., 2012; Kelly et al., 2013). Also, low quality reviews did not perform study selection (Lua & Wan, 2012; Laska et al., 2012) and data extraction in duplicate (Lua & Wan, 2012; Laska et al., 2012; Kelly et al., 2013) and failed to declare any conflicts of interest (Lua & Wan, 2012; Kelly et al., 2013). The application of the AMSTAR 2 assessment of the methodological quality of each review are presented in Table 4.3.

Table 4. 3. Application of the AMSTAR 2 methodological quality criteria on the identified reviews targeting dietary, physical activity and weight-related outcomes in university students

Systematic Reviews	**Christoph & An (2018)**	**Maselli et al. (2018)**	**Deliens et al. (2016)**	**Roy et al. (2015)**	**Plotnikoff et al. (2015)**	**Kelly et al. (2013)**	**Lua & Wan (2012)**	**Laska et al. (2012)**
AMSTAR 2 Criteria								
1. Did the research questions and inclusion criteria for the review include the components of PICO?	Yes	No	Yes	Yes	Yes	No	No	No
2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?	No	Partial Yes	No	No	No	No	No	No
3. Did the review authors explain their selection of the study designs for inclusion in the review?	No	Yes	No	No	No	Yes	No	No
4. Did the review authors use a comprehensive literature search strategy?	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes
5. Did the review authors perform study selection in duplicate?	No	Yes	Yes	Yes	Yes	Yes	No	No
6. Did the review authors perform data extraction in duplicate?	No	Yes	Yes	Yes	Yes	No	No	No
7. Did the review authors provide a list of	Yes	Yes	No	Yes	No	Yes	No	No

Systematic Reviews	**Christoph & An (2018)**	**Maselli et al. (2018)**	**Deliens et al. (2016)**	**Roy et al. (2015)**	**Plotnikoff et al. (2015)**	**Kelly et al. (2013)**	**Lua & Wan (2012)**	**Laska et al. (2012)**
excluded studies and justify the exclusions?								
8. Did the review authors describe the included studies in adequate detail?	Yes	Yes	Partial Yes	Yes	Yes	No	Partial Yes	Yes
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?	Yes	Yes	Yes	Yes	Yes	No	No	No
10. Did the review authors report on the sources of funding for the studies included in the review?	No	No	Yes	Yes	Yes	No	No	No
11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?	Yes	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	Yes	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	No	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?	Yes	Yes	Yes	Yes	Yes	No	No	No
14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

Systematic Reviews	**Christoph & An (2018)**	**Maselli et al. (2018)**	**Deliens et al. (2016)**	**Roy et al. (2015)**	**Plotnikoff et al. (2015)**	**Kelly et al. (2013)**	**Lua & Wan (2012)**	**Laska et al. (2012)**
review?								
15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	No	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	Yes	Yes	No	Yes	Yes	No	No	Yes
Overall quality assessment	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Critically Low**	**Critically Low**	**Critically Low**

4.6.3 Synthesis of findings across reviews

4.6.3.1 Types of intervention within individual studies

The different types of intervention reported in studies across reviews are summarised and presented in Table 4.4. For each type of intervention, a number of sub-types of intervention were identified, giving a total of fourteen different types of intervention, within the four main groups.

Environmental interventions

Thirty-six studies using an environmental intervention were identified from the reviews (Appendix II.B, Supplemental Table 1). Twenty-eight provided nutrition information through labelling or other signage at point-of-purchase (POP). Examples include the studies by Turconi et al. (2012) and Hoefkens et al. (2011) who used posters, food pyramids or a star rating system at the university cafeterias to encourage purchases of healthy foods or the study by Bergen & Yeh (2006), which used posters on vending machines to promote sales of healthy beverages (e.g. water). Four interventions provided price incentives including cash rebates (Cinciripini, 1984), distributed free items (Lachat et al., 2009) or reduced price for healthy options (Michels et al., 2008; Cárdenas et al., 2015). Two studies reduced the portion size of unhealthy foods (e.g. snacks) (Stroebele et al., 2009; Freedman & Brochado, 2010), one increased the availability of targeted foods in fairs (Shive & Morris, 2006) and one offered sample plates (McClain et al., 2013).

Face-to-face interventions

Fifty-one studies using a face-to-face intervention were identified from the reviews (Appendix II.C, Supplemental Table 2). Thirty-one used in-class interventions, including educational programmes/courses or workshops and seminars. Most courses were delivered throughout one academic semester. The majority of interventions included lecturing, practice, group discussions, problem solving and assigned homework with feedback. Examples are the studies by Claxton & Wells (2009) and Pearce & Cross (2013). Many courses were structured on behaviour-change theories. For instance, the study by Ince (2008) used social cognitive theory to increase self-regulation, social-support and perceived enjoyment toward physical activity while the study by Schnoll & Zimmerman (2001) used the same theory to improve knowledge and perceived confidence in following a dietary behaviour. Eight studies used tailored interventions based on individual's requirements, beliefs and current practices, followed by personal feedback. For instance, Brinberg et al. (2000) used tailored messages based on participants' baseline information, Martens et al. (2012) used one-to-one brief motivational consultations while Bowden et al. (2007) provided each participant tailored dietary and physical activity prescriptions. Five studies used peer-training, where qualified students (peers) provided education and guidance to participating students. Examples include the studies by King et al. (2013) and White et al. (2009). Two studies used both peer and in-class education (Sallis et al., 1999; Boyle et al., 2011) while others used cooking classes (Levy & Auld, 2004), activities within residence buildings (Brown et al., 2014a) and motivational/instructional brochures (Bray & Born, 2004).

E-interventions

Thirty studies using an e-intervention were identified from the reviews (Appendix II.D, Supplemental Table 3). Twenty-three delivered educational programmmes through the world wide web. Examples include the studies by Epton et al. (2014) and Franko et al. (2008) where students received access to online educational resources (text, links, videos), theory-based messages, rating assignments and tailored feedback. Other e-interventions used email messages with tailored feedback (Gow et al., 2010), online cooking programmes (Brown et al., 2011), support through social media (Cavallo et al., 2012) and e-counselling (Harvey-Berino et al., 2012). Many e-interventions were also structured on behaviour-change theories. Examples include the study by Parrott et al. (2008), who used the theory of planned behaviour, including positive/negative framed messages and the study by Kattelmann et al. (2014), who used a theoretical Model of Instructional Design to structure their online lessons. Seven interventions used technology equipment, one sent behaviour-directed motivational text messages via mobile phones (Brown et al., 2014b) and six provided a device (usually a pedometer) to track daily steps such as in the studies by Jackson & Howton (2008) and Tully & Cupples (2011).

Combined interventions

Five studies using a combination of the above modes of interventions were identified from the reviews (Appendix II.E, Supplemental Table 4). One used two peers working together and online logbooks to track behaviour (Cholewa & Irwin, 2008), one performed in-person meetings with counsellors enhanced by giving students access to online materials and a pedometer to track steps (Mailey et al., 2010), and one used tailored motivational consultations followed by email messages and access to online resources (Richards et al., 2006). Two studies used an environmental approach by modifying the calories of the cafeteria menu or providing POP information, together with group and/or peer education (Musgrave & Thornbury, 1976; Evans & Mary, 2002) accompanied by supplemental online materials in one study (Evans & Mary, 2002).

Table 4. 4. Classification of types and sub-types of interventions of studies in identified reviews aiming to improve dietary, physical activity and weight-related outcomes in university students

Type of intervention (n, number of studies)	**Brief description of intervention subtypes** (n, number of studies)
Environmental interventions (n=36)	Nutrition information through labelling or other signage (e.g. posters, pyramids) at point-of-purchase points at university cafeterias or other food places (n=28) Price incentives (e.g. cash rebate, free items or reduced price) for healthy food/meals options (n=4) Reduced portion size of unhealthy foods/meals (n=2) Increased availability of targeted healthy foods for sale (n=2)
Face-to-face interventions (n=51)	Educational programmes/courses, workshops or group seminars delivered in-class (n=31) Tailored motivational consultations or prescriptions (n=8) Peer-training, i.e. qualified students (peers) providing education and guidance to participating students (n=5) Mixed (peer plus in-class education) (n=2) / other approaches (cooking classes, activities within residence buildings, motivational/instructional brochures/leaflets) (n=5)
E-interventions (n= 30)	Educational programmes delivered through the world wide web (n=23) Technology-based interventions using mobile phones, pedometers, accelerometers, etc. (n=7)
Combined modes of interventions (n=5)	Peer-education plus online tools (n=1) Tailored consultation plus online education (n=2) Environmental approach plus group and/or peer education (n=1) Environmental plus peer education plus online materials (n=1)

4.6.3.2 Types of outcomes within individual studies

Six main types of outcome were identified within the different types of interventions and are summarised in Table 4.5. Physical activity behaviour outcomes were the most frequently reported (112 of 384 outcomes) (29%) and dietary intake outcomes the second most reported (94 of 384 outcomes) (24%), with cognitive variables of dietary behaviour being the least frequently reported outcomes (25 of 384 outcomes) (7%). Food sales (61 outcomes) were outcomes of interest only in environmental approaches. Environmental interventions also targeted dietary intakes with only one study assessing dietary cognitive variables (customers' intention to repurchase and rating of food quality) and one study assessing body weight changes.

Table 4. 5. Types of outcomes used to assess effectiveness of interventions in studies from identified reviews aiming to improve dietary, physical activity and weight-related outcomes in university students.

Outcomes (n, total number of outcomes)	**Brief description of desired outcomes**	**Types and number of interventions targeting the outcomes**
Food sales (n=61)	Increases in sales of healthy foods/meals/drinks or decreases in sales of unhealthy foods/meals/drinks.	Environmental: n=20
Dietary intakes (n=94)	Increases in intakes of foods/nutrients beneficial to health or decreases in intakes of foods/nutrients harmful to health when consumed in excess amounts as well as improved overall eating habits and diet quality.	Environmental: n=15 Face-to-face: n=21 E-interventions: n=10 Combined: n=2
Cognitive variables towards dietary behaviour (n=25)	Increases in perceived skills (e.g. self-efficacy, goal setting), knowledge, attitudes, social support or decreases in perceived barriers towards healthy eating behaviour. Also, positive ratings on food quality and intention to repurchase.	Environmental: n=1 Face-to-face: n=7 E-interventions: n=6 Combined: n=1
Physical activity behaviour (n=112)	Increases in frequency, duration, intensity, energy expenditure of activity, fitness level or specific types of activities or decreases in sedentary behaviour	Face-to-face: n=21 E-interventions: n=20 Combined: n=1
Cognitive variables towards activity behaviour (n=59)	Increases in perceived skills (e.g. stage of change, coping, outcome expectations), social support, knowledge/attitudes or decreases in perceived barriers towards activity goals.	Face-to-face: n=6 E-interventions: n=15
Weight-related (n=33)	Favourable changes in BMI or/and body composition variables (body mass, body fat, waist circumference, waist to hip ratio) or prevention of weight gain.	Environmental: n=1 Face-to-face: n=9 E-interventions: n=8 Combined: n=1

4.6.3.3 Overall effect of individual studies according to the types of intervention

Environmental interventions

For all environmental interventions identified in this overview, the sum of improved outcomes for food sales was 32/61 (53%) and 22/47 (47%) for dietary intakes, representing a moderate effect (Appendix II.B, Supplemental Table 1). Comparing these findings to those of individual reviews (Table 4.2), Deliens et al. (2016) reported that 5 out of 7 environmental interventions (71%) improved dietary intakes while Roy et al. (2015) and Kelly et al. (2013) found that 13 out of 15 (87%) and all (3/3) environmental interventions respectively, were effective at improving various dietary outcomes. The overall effect of environmental interventions and according to subtypes is presented in Table 4.6.

Examining the effect of intervention subtypes, this overview found that environmental interventions that provided POP information through food labelling or other signage had a moderate effect on both food sales (46% of outcomes improved) and dietary intakes (44% of outcomes improved). These rates were lower than the ones reported by Christoph & An (2018) as well as Roy et al. (2015), who found that 16 out of 21 (76%) and 8 out of 10 (80%) POP interventions respectively were effective at improving food sales or dietary intakes. Findings of this overview also suggest that overall interventions that increased availability, controlled portion size or provided price incentives had a high effect on sales of specific foods/drinks/meals by improving 89% of outcomes, and a moderate effect on dietary intakes by improving half of outcomes (55%). Again, these rates were lower than those reported by Roy et al. (2015), who found that all (3/3) studies that increased availability or reduced portion size improved dietary intakes. The overview also found that one environmental (POP) intervention had a positive impact on weight gain prevention and another on participants' rating of food quality and intention to repurchase, however, due to the limited number of identified studies, no reliable conclusions could be drawn for these outcomes.

Face-to-face interventions

Examining all face-to-face interventions identified in this overview together, the sum of improved dietary intake outcomes was 28/65 (43%) and 15/18 (83%) for the related cognitive variables (Appendix II.C, Supplemental Table 2). Comparing these findings to those of individual reviews (Table 4.2), Deliens et al. (2016) reported that 2 out of 6 (33%) face-to-face (=interpersonal) interventions were effective at improving dietary intakes while Kelly et al. (2013) and Lua & Wan (2012) found that 5 out of 6 (83%) and 13 out of 14 (93%) respectively, improved a mix of cognitive and behavioural dietary outcomes. In relation to physical activity, the sum of improved outcomes in this overview was 22/69 (32%) for behaviour, 2/14 (14%) for cognitive outcomes and 11/18 (61%) for weight-related outcomes. Comparisons with individual reviews could not be made as none investigated the impact of any type of intervention on physical activity. The overall effect of face-to-face interventions and according to subtypes is presented in Table 4.6.

Within the subtypes of face-to-face interventions, the findings of this overview suggest that interventions delivered in-class had a moderate effect on dietary and physical activity behaviour (55% and 34% of outcomes improved), a high effect on dietary cognitive and weight-related outcomes (100% and 75% of outcomes improved) but no effect on physical activity cognitive outcomes (none of the outcomes improved).

In comparison to findings of individual reviews (Table 4.2), Laska et al. (2012) also found a high effect on weight-related outcomes by reporting that 5 out of 6 (83%) class-based courses were effective.

This overview also suggests that interventions including tailored consultations had a low effect on dietary intakes (8% of outcomes improved), a moderate effect on physical activity behaviour (35% of outcomes improved), and a high effect on weight-related outcomes (67% of outcomes improved). Interventions using peers as educators were generally ineffective towards all types of outcomes while the use of integrated face-to-face approaches had a moderate to high effect on all outcomes, except physical activity behaviour (low effect). However, the interpretation of results of peer training or mixed face-to-face approaches on weight-related outcomes should be made with caution due to the limited number of reported outcomes. Comparisons with individual's reviews cannot be made, as none investigated the effectiveness of these subtypes (tailored or peer-training) of face-to-face interventions.

E-interventions

For all e-interventions identified in this overview, the sum of improved outcomes was 8/24 (33%) for dietary intakes, 11/16 (69%) for dietary cognitive variables, 10/43 (23%) for physical activity behaviour, 13/45 (29%) for physical activity cognitive outcomes and 4/13 (30%) for weight-related outcomes (Appendix II.D, Supplemental Table 3). Within e-interventions, those delivered through the world wide web had a high effect on dietary cognitive outcomes (79% of outcomes improved), a moderate effect on dietary intakes (35% of outcomes improved) and weight-related outcomes (57% of outcomes improved) and a low effect on physical activity outcomes (both behavioural and cognitive) (20-24% of outcomes improved). In comparison to findings of the individual reviews (Table 4.2), Deliens et al. (2016) reported that 5 out of 6 (83%) web-based interventions improved dietary intakes while Kelly et al. (2013) found that 3 out of 5 (60%) online interventions improved a mix of dietary outcomes. This overview also found that using technology was generally ineffective, except for physical activity cognitive outcomes by improving 3/4 (75%) outcomes. Due to the limited number of technology-based studies and reported outcomes, interpretation of results should be made with caution. No individual reviews were found to have reported the effectiveness of technology-based e-interventions to make comparisons. The overall effect of e-interventions is presented in Table 4.6.

Combined interventions

The findings of this overview suggest that interventions that used a combination of the above approaches improved 3 out of 4 dietary intake and 1 out of 2 dietary cognitive outcomes (Appendix II.E, Supplemental Table 4). Due to the limited number of studies and reported outcomes, interpretation of results should be made with caution. The overall effect of combined interventions is presented in Table 4.6.

Table 4. 6. Overall effect of environmental, face-to-face, e-interventions and combined modes of interventions of studies identified from reviews targeting dietary, physical activity and weight-related outcomes in university students

	Sum of improved outcomes out of the sum of outcomes reported, x/y (%)[1]											
	Environmental interventions			Face-to-face interventions					E-interventions			Combined modes of interventions
Outcomes	All environmental interventions	Information through labelling and other signage	Increasing availability/ control portion size/ price incentives	All face-to-face interventions	In-class	Tailored	Peer-training	Mixed/ other	All e-interventions	Delivered through the world wide web	Using technology	All combined interventions
Food sales	**32/61 (52.5)**	24/52 (46.2)	8/9 (88.9)	-	-	-	-	-	-	-	-	-
Dietary intakes	**22/47 (46.8)**	16/36 (44.4)	6/11 (54.5)	**28/65 (43.1)**	23/42 (54.8)	1/12 (8.3)	1/7 (14.3)	3/4 (75.0)	**8/24 (33.3)**	7/20 (35.0)	1/4 (25.0)	**3/4 (75.0)**
Cognitive variables toward dietary behaviour	**2/2 (100)**	2/2 (100)	-	**15/18 (83.3)**	11/11 (100)	-	1/4 (25)	3/3 (100)	**11/16 (68.8)**	11/14 (78.6)	0/2 (0.0)	**1/2 (50.0)**
Physical activity behaviour	**-**	-	-	**22/69 (31.9)**	12/35 (34.3)	6/17 (35.3)	0/4 (0.0)	4/13 (30.8)	**10/43 (23.3)**	6/30 (20.0)	4/13 (30.8)	-

	Sum of improved outcomes out of the sum of outcomes reported, x/y (%)[1]											
	Environmental interventions			Face-to-face interventions					E-interventions			Combined modes of interventions
Outcomes	All environmental interventions	Information through labelling and other signage	Increasing availability/ control portion size/ price incentives	All face-to-face interventions	In-class	Tailored	Peer-training	Mixed/ other	All e-interventions	Delivered through the world wide web	Using technology	All combined interventions
Cognitive variables toward activity behaviour	**-**	-	-	**2/14 (14.3)**	0/5 (0.0)	-	1/7 (14.3)	1/2 (50.0)	**13/45 (28.9)**	10/41 (24.4)	3/4 (75.0)	-
Weight-related outcomes	**1/1 (100)**	1/1 (100)	-	**11/18 (61.1)**	6/8 (75.0)	4/6 (66.7)	0/2 (0.0)	1/2 (50.0)	**4/13 (30.1)**	4/7 (57.1)	0/6 (0.0)	**0/1 (0.0)**

[1]The sum of improved outcomes out of the sum of all outcomes suggesting a positive effect

4.7 Discussion

4.7.1 Identified interventions and outcomes

The aim of this overview was to identify systematic reviews of studies aiming to improve dietary, physical activity or weight-related outcomes in university students, to identify the different types of interventions used and outcomes assessed and estimate the overall effect of the different types of intervention. Eight reviews were identified of which two focused on food purchases/choices, three on diet, one on physical activity, one on body composition and one targeted all types of outcomes. The reviews included 122 studies in total, most of which had moderate quality, as judged by review authors. The types of interventions identified across all studies were grouped into face-to-face (n=51), environmental (n=36), e-interventions (n=30) or combined approaches (n=5). The types of outcomes reported across individual studies were food sales (n=61), dietary intakes (including overall eating habits and diet quality) (n=94), cognitive dietary behaviour variables (n=25), physical activity behaviours (n=112), cognitive variables towards physical activity behaviour (n=59) and weight-related outcomes (n=33). Of the 122 identified studies, only 7 were implemented in the UK of which two applied an environmental approach (Aaron et al., 1995; Nikolaou et al., 2014), two followed a face-to-face approach (Chapman et al., 2009; Zhang & Cooke, 2011) and three used e-interventions (Skår et al., 2011; Tully & Cupples, 2011; Epton et al., 2012).

In-class lecturing with interactive learning remains the most common teaching method used for educational purposes (Schmidt et al., 2015), which could explain the high number of this type of intervention identified in this overview (31 of 51 studies of face-to-face interventions). Environmental interventions require modifications to the university settings as well as the involvement and collaboration of the food catering services, which could be challenging for profit reasons. The use of technology and the world wide web in higher education has increased the last decades, however, it is mainly used to complement traditional educational methods (Eynon, 2008). As expected, changing dietary and physical activity habits were the outcomes with the highest levels of reporting, as literature has shown the long-term benefits in health by the adoption and maintenance of a healthy diet and activity pattern in early adulthood (Deforche et al., 2015). Many studies also aimed to improve mediators of dietary and activity behaviour in an attempt to improve understanding (Schnoll & Zimmerman, 2001) or enhance the impact of cognitive changes on behaviour (King et al., 2013). Food sales were outcomes of interest only in environmental interventions. These interventions also targeted dietary intakes, but no environmental interventions were identified that targeted physical activity and only one targeted body weight (Nikolaou et al., 2014). A large number of studies focused on weight gain prevention as was expected, considering the evidence showing that many students gain on average 3.85 kg during their first year in college (Vella-Zarb & Elgar, 2009). The majority of interventions had a short duration, lasting from a couple of minutes (Skår et al., 2011) to several weeks or months with very few continuing for more than two years to assess long term outcomes (Evans & Mary, 2002; Cioffi et al., 2015). The use of short-term outcomes acts as surrogates for the longer-term ones, but the high amount of time and cost taken to implement long term studies can justify the relatively low number of studies identified.

4.7.2 Overall effect of studies

Environmental interventions, in particular POP interventions, had a moderate effect on dietary intake and food sales (~45%). The reviews by Christoph & An (2018) and Roy et al. (2015) found an overall effect of 75% and 80% for food labelling, respectively. These rates are 1.7 times higher than the ones found in this overview. This is partially explained by the different methodology followed by reviewers to estimate effectiveness (i.e. reviewers reported as effective any intervention that favourably changed at least one of the outcomes of interest) but also by the fact that both reviews identified a lower number of studies than the number of individual studies analysed in this overview, which might have resulted from failings in the searching and study identification stages of each review. An interrupted time series design was followed by most environmental interventions, with many lacking randomisation and specification of sample size, whilst the reliability of results is highly dependent on the method used to analyse the data (Ewusie et al., 2017). In addition, counting food sales might be inaccurate, as purchasing food/drinks does not necessarily result in their consumption or indeed their consumption by the buyer (Appelhans et al., 2017).

Face-to-face interventions, particularly in-class courses, had a moderate effect on dietary intakes (43-55%) and a high effect on related cognitive variables such as knowledge, attitude and self-efficacy (83-100%). When comparing to results of reviews that investigated face-to-face interventions, Deliens et al. (2016) reported a low effect on dietary intakes (33%) while Kelly et al. (2013) and Lua & Wan (2012) a high effect (83% and 93%, respectively) on dietary outcomes (both intakes and cognitive). The review by Deliens et al. (2016) identified only six interventions while in this overview twenty-one studies were analysed, suggesting that Deliens et al. (2016) failed to identify studies which were included in other reviews and may have contributed to bias in the conclusions drawn. The fact that Kelly et al. (2013) and Lua & Wan (2012) drew conclusions by assessing dietary intake and cognitive outcomes together, could explain the high effect found, as cognitive variables skewed the results towards higher rates. One should also consider that methodological quality was found critically low in both reviews.

With regards to e-interventions, the findings of this overview suggest a moderate effect on dietary intakes (33-35%) and a high effect on related cognitive variables (69-79%). The review by Deliens et al. (2016) found that almost all web-based studies were effective (83%) while Kelly et al. (2013) found a moderate effect (60%). Both reviews identified a lower number of web-based studies compared to this overview, where 10 studies assessing dietary intakes [versus n=5 in Deliens et al. (2016)] and 16 studies, assessing both dietary intakes and cognitive variables [versus n=6 in Kelly et al. (2013)], were included in the analysis.

Both face-to-face and e-interventions had a low effect on physical activity behaviour (32% and 23%, respectively) and related cognitive variables (14% and 29%, respectively). Interestingly though, the use of technological equipment such as accelerometers and pedometers improved awareness and other cognitive mediators towards exercise (effect rate 75%). The reviews by Maselli et al. (2018) and Plotnikoff et al. (2015) found a moderate impact of interventions on physical activity (~60%), however, they did not present their results by the type of intervention or separate cognitive from behavioural aspects thus, direct comparisons cannot be made with the findings of this overview.

Regarding body composition, both face-to-face and e-interventions had a low to moderate effect (30-60%). The review by Plotnikoff et al. (2015) also reported a low number of effective studies (33%) opposite to Laska et al. (2012), which found a high effect (75%). The critically low methodological quality in addition to the country limits at the study selection stage applied by Laska et al. (2012) could somehow explain the results found by the reviewer. Many studies, presumably for increasing the ease of data collection, used self-reported measures of body weight and BMI (Brinberg et al., 2000; Schnoll & Zimmerman, 2001; Ince, 2008; Pearce & Cross, 2013) decreasing the accuracy of overall conclusions.

In general, the findings of this overview suggest that the interventions identified had a higher effect on cognitive outcomes than on behavioural outcomes. The literature suggest that interventions structured on social psychological models seem to have a higher effect on behaviour change compared to interventions with little use of such models (Webb et al., 2010). Many studies included in the reviews structured their interventions upon behavioural models in an attempt to improve cognitive outcomes that enact the behaviour of individuals (Brown et al., 2014a; Hall et al., 2016). Such theorical models include the Social Cognitive Theory, the Transtheoretical Model and the Theory of Planned Behaviour (known also as Reasoned Action), with the latter being widely used to predict dietary behaviours (Riebl et al., 2015). The Theory of Planned Behaviour is based on the rationale that an individual's attitudes and knowledge toward behaviour, subjective norms and beliefs as well as perceived behavioural control, predict and shape the individual's intention to engage in a behaviour, which is strongly correlated with the individual's actual behaviour (Ajzen, 1991). In this overview, cognitive variables identified such as self-efficacy, perceived social support, perceived barriers, knowledge and attitudes were targeted in studies to enhance positive changes in dietary and physical activity behaviour. The findings of this overview suggest that although interventions were effective in changing these cognitive variables, they were less effective in changing the actual behaviour of students. This might be explained by the limitations and gaps of this theory. In particular, the theory of Planned Behaviour does not consider other factors that predict behaviour such as the environment, affordability, personal characteristics, past experiences/habits as well as the available resources and skills for performing the behaviour (Ajzen & Madden, 1986). In addition, it does not account for moral and religious beliefs (Godkin & Kok, 1996) or other factors (e.g. time frame) that affect the link between intention and behaviour performance (Corner & Armitage, 1998). As discussed in the **Literature Review** (Chapter 2, sections 2.4.3 and 2.5.5), the dietary and physical activity behaviour in students is influenced by a cluster of individual (taste, time, convenience, stress), social (family, peers, friends), environmental (availability, accessibility, cost) and media (advertising) factors (Deliens et al., 2014; Deliens et al., 2015a). These factors might diminish the beneficial influence of cognitive mediators on behaviour change. Additional methodological reasons that might explain the low effect found on behavioural outcomes compared to cognitive outcomes might be the fact that assessment of behaviour is more challenging than assessment of cognitive variables. In most studies, cognitive variables were measured by Likert scales, and ratings were solely based on individual perceptions while dietary and physical activity behaviour were usually assessed by questionnaires, which are susceptible to literacy and recall bias (Willet, 2012). Also, most studies lasted for a couple of weeks or months, which might not be enough time to engage and maintain a behaviour.

Of the identified non-environmental reviews, four (Lua & Wan 2012; Kelly et al. 2013; Plotnikoff et al. 2015; Maselli et al. 2018) reported both cognitive and behavioural outcomes with none investigating whether the theoretical constructs used in the interventions were associated with the targeted cognitive variables and whether significant changes in cognitive variables affected the relevant behaviour in students. This phenomenon is discussed in a similar meta-analysis of interventions targeting dietary and physical activity outcomes, which found that only 56% of the identified studies (n=190) reported using a theoretical model of which, 90% failed to report links between the theoretical constructs and the behaviour change techniques or between the type and extent of theory used and effectiveness of interventions (Prestwich et al., 2014). Therefore, when researchers design complex interventions targeting cognitive and behavioural outcomes, they should establish whether a theoretical model was used to develop the intervention and whether the theoretical constructs affected the effectiveness of the intervention.

One way to report the use of theoretical models in the development and evaluation of health-behaviour interventions is to apply the Theory Coding Scheme developed by Michie & Prestwich (2010). The scheme includes 19 items of which the first 11 report whether a theory is mentioned (items 1 to 3), whether the relevant theoretical constructs are targeted (items 2, 5, 7-11) and whether the theory is used in the selection of potential participants or to tailor the intervention (items 4 and 6). Items 12-14 assess whether the theoretical constructs have been measured before and/or after the intervention using valid and reliable methods and randomisation of participants has occurred; items 15-18 assess whether the intervention significantly changed any of the targeted behavioural constructs and whether the change in cognitive outcomes mediated any change of behaviour. Finally, items 17-19 report whether the results are summarised and critically discussed considering the use of theory and they are used to refine theory. Interventions targeting health outcomes, as well as systematic reviews and meta-analyses including them, should apply the aforementioned coding scheme in order to investigate how the theoretical models are used and linked with the interventions and whether they predict and mediate changes in the behavioural outcomes. This will allow to estimate whether using theory-based interventions are more effective than interventions not based on theories and explain further the impact of cognitive outcomes on behaviour change by investigating potential mediating effects. However, finding a mediation between cognitive and behavioural outcomes does not state a causal relationship and other methods (e.g. adding or removing the potential mediator in experimental groups and looking for differences in effectiveness) might be needed to establish a causal relationship when evaluating the effectiveness of interventions (Michie & Prestwich, 2010; Michie et al., 2018).

4.7.3 Methodological quality of reviews

The application of AMSTAR 2 criteria resulted in five reviews being of moderate quality and three reviews being of critically low quality. As some of the results in this overview were based on results reported by reviewers, the methodological quality of reviews had a direct impact on the findings of this overview. Almost all reviews limited their search to articles written in the English language and did not extend their search to grey literature while data selection and extraction in two reviews were conducted by one reviewer. Thus, studies might have been omitted by reviews, and, although it was out of the scope of this overview, we noticed that reviews with apparently similar eligibility criteria had a high number of uncommon studies. Additionally, none of the reviewers assessed publication bias. Empirical evidence suggests that journals or researchers tend to underreport manuscripts with null or unfavourable results (Song et al., 2013). Absence of studies with negative results or null findings from reviews may result in the findings seeming overly favourable. Assessment of the risk of bias of studies was performed by five out of eight reviews while risk of bias was not considered in reviews that pooled results in a meta-analysis. It is not clear to what extend the quality impacts the outcome of a study; nevertheless, assessing risk of bias is vital for interpreting the results and making strong recommendations (Atkins et al., 2004).

Assessment of heterogeneity and pooled analysis of data was performed in only two reviews, with many reviews being unclear whether an attempt was made to assess heterogeneity and perform a meta-analysis. Many reviews failed to report conflict of interest or state the potential funding bias of their included studies. Although the nature of research of studies is non-profitable, the funding sources should be reported and taken into consideration. Finally, a relationship seems to emerge between the number of effective studies found by reviews and their methodological quality as the three reviews that scored very low (Lua & Wan, 2012; Laska et al., 2012; Kelly et al., 2013) identified almost exclusively effective studies (>75%).

4.7.4 Strengths and limitations of the overview process

The review was conducted following the PRISMA guidelines with no restrictions applied with regards to publication status, date or language. However, there was no pre-registered protocol. Two reviewers worked independently to assess eligibility and extract data from full-text identified reviews, reducing potential bias in the overview process. Reviews with a pooled and narrative synthesis were eligible for inclusion with many reviews choosing not to report effect size or statistical significance of changed outcomes. Some reviews were focused only on behavioural outcomes while others investigated a mix of cognitive and behavioural variables, making the synthesis of results in a meta-analysis very difficult. When a pooled synthesis of findings cannot be conducted, a least preferable method suggested by The Cochrane Handbook is vote counting (Higgins & Green, 2011). Vote counting reports the direction of effect (positive, negative or no change) of a reported outcome but cannot draw any conclusion about the effect size or statistical significance of the changed outcome (Flodgren et al., 2011). In this overview, vote counting was used to derive an estimate of the overall effect of studies by calculating the sum of outcomes improved out of the total number of outcomes reported. There are weaknesses inherent in this method in that it can be difficult to judge whether the results of a study are positive or negative and decisions are subjective. Despite this limitation, this method is likely more objective than the one used by individual reviewers, who reported as effective any study with favourable improvements in at least one of the outcome(s) of interest, a method likely to introduce selective reporting bias. An additional weakness of the vote counting method is that, unlike meta-analysis, it fails to take into account the weighting of individual studies and this is a weakness of this synthesis.

In this overview, behavioural and cognitive variables were analysed separately when estimating overall effect, increasing the reliability of overall findings. Also, new (sub)groups of the main modes of interventions were introduced and their overall effect on the various outcomes was calculated. However, the methods and units used to assess the outcomes in studies as well as the methodological quality of reviews were not considered in data synthesis and analysis, introducing potential bias in the overview process and findings.

4.7.5 Conclusion and implications of the overview

By conducting the overview of systematic reviews, the PI gained a significant amount of knowledge with regards to the characteristics of the different types of interventions and outcomes reported in studies. In addition, the overview provided an estimate of the overall effect of each (sub-)type of intervention toward the different health outcomes and the impact of the type of outcome (cognitive versus behavioural) on the effectiveness of an intervention. Since one of the objectives of the thesis was to increase nutrition knowledge, diet quality and physical activity in university students, the findings of this overview were used to decide towards the design and development of the appropriate type of intervention to improve these outcomes. In particular, the findings of this overview suggest that both face-to-face (mainly in-class) and e-interventions (delivered through the world wide web) demonstrated a moderate effect towards dietary intake variables (e.g. diet quality), a high effect towards dietary cognitive variables (e.g. nutrition knowledge) and a low effect towards physical activity behaviour. Based on these findings and considering the advantages of using the internet to educate and promote health in young adults (Chapter 2, section 2.8), the PI chose to implement an online educational programme (e-programme) as part of this research project (Chapter 6).

In general, researchers could use the findings of this overview when developing and implementing interventions that aim to improve cognitive or behavioural variables in relation to diet or exercise as well as body composition among university students. Despite difficulties, research should aim at conducting long-term interventions and attempt to synthesise findings to get a pooled estimate of changes. A mixed methods research design should be considered for future studies not only to assess the impact of interventions but also to capture the experiences and views of students on acceptability and feasibility of the interventions and explain the variation observed across studies. Finally, it is interesting to explore the potential reasons for the very low effect of all types of interventions towards physical activity outcomes in order to design more successful interventions in the future.

The findings of this overview also inform public health policy makers and members of the Healthy Universities Initiative regarding activities that could be applied within university settings to improve the health and well-being of students. In particular, the overview suggests that universities should intervene with the restaurants and food shops to increase information and availability of healthy options and if possible, decrease the prices of healthy items. These actions should further be enhanced by short-term class-based courses to increase awareness, skills and advice towards a healthy diet and body weight and online resources where students could use anytime as a source of evidence-based information. Decision makers should avoid using students as role models or training other students, as peer-training was not effective according to this overview. Finally, universities should consider providing tailored counselling for students with body weight concerns as the overview suggests that tailored interventions benefit mainly weight-related outcomes.

Chapter 5. Nutrition knowledge among university students in the UK: a cross-sectional study

5.1. Overview of the chapter

As presented in the **Literature Review** of the thesis (Chapter 2, section 2.6.1), nutrition knowledge can significantly influence dietary behaviour. The cross-sectional studies presented in Chapter 2 (section 2.6.2) found that students demonstrated a moderate level of nutrition knowledge with the majority of studies taking place outside the UK. The current research project implemented a cross-sectional study in the UK to provide insights in the level of nutrition knowledge of students and contribute towards the design of successful health-promoting interventions in the future. In this chapter, the methodology and results of the cross-sectional study are presented. In particular, the current study demonstrated which nutritional aspects students were knowledgeable about, factors affecting their knowledge, predictors of a 'good knowledge' as well as whether a higher level of nutrition knowledge was associated with improved diet quality. The overall findings were compared and discussed, including potential methodological limitations and implications for future research in the field.

5.2. Introduction

A high level of nutrition knowledge in university students has been found to positively associate with an increased intake of fruit, dairy, protein and wholegrain foods (Kolodinsky et al., 2007) or other dietary behaviour (i.e., reading food labels) (Cooke &

Papadaki, 2014). As reported in the **Literature Review** (Chapter 2, section 2.6.8), factors such as family and peers, academic stress, lack of time, religious beliefs and/or the cost of food can influence the dietary habits of students (Deliens et al., 2014; Pelletier et al., 2014). As the impact of some of these factors on dietary behaviour cannot be modified, by increasing the knowledge of students with regards to nutrition and healthy eating, students are given the opportunity to personalise this knowledge and apply it to their daily lives. In some studies, having received nutrition education (Mazier & Mcleod, 2007) or studying a course with some exposure to nutrition (Al-Naggar & Chen, 2011) was associated with increased nutrition knowledge in students. Considering that students from non-health scientific disciplines (e.g. political sciences, mathematics) might never have the chance to receive nutrition information via their courses, it is important to include nutrition knowledge in any health-promoting strategy.

According to the findings of the cross-sectional studies reported in the **Literature Review** (Chapter 2), students seem to acquire a moderate level of nutrition knowledge (Table 2.3). In particular, students demonstrated inadequate knowledge, by answering less than half of the questions correctly, regarding fruits and vegetables (Matthews et al., 2016), milk or their alternatives and fermented dairy products (Matthews et al., 2016), vitamin D (Boland et al., 2015; Zhou et al., 2016), food labels (Misra et al., 2007) and the impact of diet on chronic diseases (Peltzer 2002; Nabhani-Zaidan et al., 2011; Cooke & Papadaki, 2014). To report the level of knowledge, researchers used a score by calculating the number of correct answers to the questions (Al-Isa & Alfaddagh, 2014). No established thresholds exist to define a good level of knowledge, with some researchers defining a good level of knowledge as any score higher than the overall mean score of their study participants (Al-Isa and Alfaddagh 2014; Folasire et al., 2016). The General Nutrition Knowledge Questionnaire (GNKQ) developed by Parmenter & Wardle (1999) is a validated tool to assess nutrition knowledge in adults and has also been used in studies with university students (Peltzer, 2002; Kresić, 2009; Barzegari, 2011; Cooke & Papadaki, 2014). Studies among university students, which assessed knowledge using the GNKQ tool, found that the mean scores of correct answers ranged from 51% to 67%, suggesting a moderate level of overall knowledge (Peltzer, 2002; Kresić et al., 2009; Barzegari et al., 2011; Cooke & Papadaki, 2014). Recently, the GNKQ questionnaire was revised in order to include updated evidence-based information on nutritional facts and dietary recommendations (Kliemann et al., 2016). To date, only one UK-based study (Cooke & Papadaki, 2014) assessed nutrition knowledge of university students, using the initial version of GNKQ while no studies were identified to have used the revised version of the questionnaire to assess knowledge in students.

5.3 Aims and objectives of the study

The aim of this study was to explore the level of nutrition knowledge in a sample of university students in the UK through the updated version of the GNKQ, investigate potential factors affecting knowledge and explore whether there is a relationship between the level of knowledge and diet quality in students (**objective 2 of the thesis**). In particular, the objectives of the study were the following:

Objective 1: Explore the current level and gaps of nutrition knowledge in a sample of university students in the UK studying both health and non-health related courses.

Objective 2: Explore potential differences in the level of nutrition knowledge of students according to socio-demographic and health factors (gender, age, ethnic origin, living status, smoking status, dieting, perceived health rating) as well as academic factors (field of study, undergraduate/postgraduate status, prior nutrition qualification).

Objective 3: Explore whether any of the above factors are predictors of a good level of nutrition knowledge in students.

Objective 4: Explore whether an increased level of nutrition knowledge is associated with a higher diet quality in students.

5.4 Methods

5.4.1 Study setting

This cross-sectional study took place in two UK higher education institutions: Kingston University (KU), London and St George's, University of London (SGUL). Both Universities are located in South West London. KU offers a variety of scientific disciplines as described in **Research Methods and Procedures** (Chapter 3, section 3.5.1). It also shares the Faculty of Health, Social Care and Education with KU, offering healthcare courses (Midwifery, Nursing, Occupational Therapy, etc.). Both universities provided the opportunity to recruit students from different scientific disciplines and allowed to investigate for potential differences in outcomes between the different disciplines. Also, both universities enrolled students from different countries and ethnic backgrounds and promoted diversity. The two universities were equipped with state-of-the-art facilities which allowed and supported the safe conduct of the research. The students' profiles of KU for the academic years 2016/7 and 2017/8, during which this study took place, are shown in Chapter 3, Table 3.1.

5.4.2 Participants

All students who were 'currently enrolled' at KU or SGUL were invited to participate in the study. The online questionnaire was open to students from all ages, independent of their mode of attendance (part-time or full time) or studying status (undergraduate or postgraduate). There were no exclusion criteria. The link of the online questionnaire was valid for completion from January 2017 until February 2018. For the purposes of this study, 200 participants were calculated as a sufficient sample size. The rationale and calculations of the sample size for this study are described in detail in **Research Methods and Procedures** (Chapter 3 section 3.5.3.1).

The study was advertised using two different methods: a) an electronic notification posted on the intranet websites of the two universities, and b) an email sent to all students through the course-directors of each Faculty. A new email address (uni-smarteating@hotmail.com) was created and used to enable potential participants to interact with the researcher to ask questions about the study. The advert message included a brief explanation about the study's aims and procedures and the link to the study's questionnaire. The voluntary nature of participating was emphasised. The completion of the questionnaire was anonymous.

5.4.3 Assessment tools and outcomes of interest

Nutrition knowledge was assessed using the revised General Nutrition Knowledge Questionnaire (GNKQ-R). The GNKQ-R assesses four sections of nutrition knowledge including dietary recommendations (18 items), nutrient sources of foods (36 items), healthy food choices (13 items), diet-disease relationships (21 items) and overall knowledge (sum of all sections, 88 items). Each correct answer gets one point (otherwise null). More details regarding the GNKQ-R questionnaire are presented in **Research Methods and Procedures** (Chapter 3, section 3.6.2).

Socio-demographic questions were also included at the end of the online questionnaire. These included questions about gender, body weight, height, age, university enrolled, studying status (e.g. undergraduate), nutrition qualification, current living status (e.g. living with parents, in a student accommodation), ethnic origin, perceived health rating, being on a special diet and whether being a smoker.

Diet quality was assessed using a semi-quantitative FFQ which calculates an Index of Diet Quality (IDQ). The FFQ includes 18 questions in relation to frequency and amount of intake of whole grain products, fat-containing foods, dairy products, vegetables and fruits, sugary foods and number of main meals skipped during the week. The IDQ score ranges from 0 to 15 points, with scores equal or less than 9 indicating a poor diet quality and scores equal or more than 10 indicating a high diet quality. The IDQ questionnaire was administered only in a sub-sample of the study (n=86) in order to investigate the relationship of knowledge with diet. More details regarding the IDQ questionnaire are presented in **Research Methods and Procedures** (Chapter 3, section 3.6.3).

5.4.4 Ethical considerations

The study was approved by the Faculty of Health, Social Care and Education Research Ethics Committee (FREC). The participant information sheet and consent form were presented online as soon as students clicked on the link of the questionnaire. Potential participants had to declare consent by ticking the appropriate boxes in order to enter the study. If consent was not provided, participants were unable to proceed with the questionnaire. All data was handled and protected according to the Data Protection Act (2009). Only the researcher and academic supervisors had access to the raw data. The questionnaire was anonymous, and it was therefore not possible to identify individual students.

5.4.5 Data analysis

5.4.5.1 Data extraction and cleaning

Data was exported from Survey Monkey software to excel spreadsheets. The data was inspected to detect incomplete, incorrect or inaccurate inputs. Additionally, the data was tested for identical double records by comparing the following socio-demographic variables: sex, age, university, faculty, living arrangement, ethnicity and smoking status (none were identified). Values on closed-ended questions such as weight and height were inspected for answers with incorrect units of measure and corrected, if possible, otherwise deleted (14 corrections on body weight and height units were made). Records with no answers to the first 18 questions (summed up to calculate score of section 1 of GNKQ-R and representing 20% of all knowledge questions) were deleted from the analysis (n=37). Initially, 301 participants entered the study of which 249 participants provided consent and completed at least 20% of the questions. A final number of 249 participants was entered for analysis. Among the 249 participants, a sub-sample (n=86) was used to test objective 4 of the study. IBM SPSS Statistics 24 software was used to perform the statistical analyses. The significance level was set for all tests at 0.05.

5.4.5.2 Handling of missing data

The datasheet was inspected to calculate the rate of missing data across the dataset. Additionally, the Little's MCAR test was performed to investigate whether the data was randomly missing or not (Little, 1998). The test failed to reject the null hypothesis, meaning that data was not randomly missing. Therefore, in the analysis, the highest number of cases in each variable was used and no imputation or other method was performed to account for the missing data.

5.4.5.3 Testing normality of data

The Shapiro-Wilk test as well as Q-Q probability and cumulative frequency plots were performed on SPSS to determine whether the data followed a normal distribution. The null hypothesis of the test was rejected ($p<0.001$), indicating that the data did not follow a normal distribution. Index of Diet Quality (IDQ) followed a normal distribution ($p=0.06$). Therefore, both parametric and non-parametric tests were used in the analysis (described below).

5.4.5.4 Description of the sample population

Descriptive statistics, showing the frequency (n) and percentage (%) of participants, were conducted to describe the characteristics of the sample regarding the following variables: age (less or more than 25 years and mean age), gender (male, female), ethnicity (White, Black, Asian, Mixed), studying status (undergraduate, postgraduate), Faculty of study (Health, Social Care and Education; Science, Engineering and Computing; Arts and Social Sciences; Business and Law; Art, Design and Architecture; Medicine and Biomedical Sciences), living arrangements [living with parent(s) or carer or other family members, sharing a house or a flat, living in student accommodation, living alone in a house or flat], having a nutrition qualification (yes, no), perceived health rating (poor/fair, good, and very good/excellent), smoking status and BMI categories (kg/m^2) (underweight, normal weight, overweight including obese).

5.4.5.5 Nutrition Knowledge

Descriptive statistics were computed to calculate the mean and standard deviation, and median and interquartile ranges of the overall GNKQ-R score and the scores of each GNKQ-R section. In each GNKQ-R section, the questions were grouped to assess knowledge about dietary recommendations, nutrient sources of foods, healthy food choices and diet-disease relationships. The sum score of these sections was used to calculate the overall nutrition knowledge score, which was used to establish the cut-off point of good nutrition knowledge and investigate the relationship between nutrition knowledge and diet quality in this study.

A different approach of analysis was used to assess knowledge on specific food groups or nutrition topics. In particular, each question of the GNKQ-R was given a number from 1 to 88 (the enumerated version of the GNKQ-R is available at Appendix I.C.ii). All questions related to a specific food group (e.g. fats and fatty foods) or a specific nutrition topic (e.g. maintain a healthy body weight) were grouped as presented in Table 5.1, and the number of participants answering all questions on each topic correctly was calculated. This analysis was used to get an estimate of students' knowledge of each nutrition topic and the findings are presented in section 5.5.3. The data from this analysis were not used to predict a good level of nutrition knowledge or investigate the potential relationship between nutrition knowledge and diet quality.

Table 5. 1. Number of questions of GNKQ-R (enumerated version) addressing a specific nutrition topic

Nutrition topic	**Number of questions on GNKQ-R enumerated version**	**Total number of questions addressing the topic**
Maintain healthy weight/ prevent weight gain	76, 77, 78, 80, 81, 82, 83, 84, 85	10
Fats and fatty foods	4, 10, 11, 12, 47, 48, 49, 50, 51, 61	10
Wholegrains/fibre	6, 30, 31, 32, 33, 34, 35, 68	8
Salt	7, 24, 25, 26, 27, 28, 29, 70	8
Sugars	2, 19, 20, 21, 22, 23, 69	7
Starchy foods	18, 42, 43, 44, 45,46	6
Protein	36, 37, 38, 39, 40, 41	6
Fruit and vegetables	1, 3, 9, 17, 60	5
Healthy meals	16, 56, 57, 58, 59	5
Food labels	65, 65, 66, 67	4
BMI/body shape	86, 87, 88	3
Dairy	13, 52, 55	3
Processed foods	5, 54	2
Cooking methods	65, 63	2
Heart disease/raised blood cholesterol	72, 74	2
Type 2 diabetes/ Glycaemic Index	73, 75	2
Oily fish	14	1
Water	8	1
Cancer	71	1
Energy	53	1
Alcohol	15	1

The number of respondents with correct answers (%) on all questions related to the specific nutrition topics were calculated. The internal consistency of the responses within each topic was calculated and reported as Cronbach’s alpha (α), with values of 0.70 or higher indicating a good reliability (the Cronbach’s alpha was not calculated in cases where there was only one question addressing a topic).

The Kruskal-Wallis non-parametric test was used to compare the median values of overall GNKQ-R scores in the various groups of students according to gender, age, BMI category, field of study, studying status living arrangement, ethnicity, nutrition qualification, being on a special diet, perceived health rating and smoking status. The significance level of tests was set at 0.05. To perform the analysis, a new categorical variable (field of study) was created based on the Faculty of study to group students into healthcare and non-healthcare field of study. The healthcare field of study included students from the Faculties of Health, Social Care and Education, those studying Medicine/Biomedical Sciences and those from other Faculties holding a nutrition qualification. Students from the remaining Faculties and with no nutrition qualification were included in the non-healthcare field of study.

Good Nutrition Knowledge

The nutrition knowledge score of the study sample was divided into quartiles, with the 75th percentile to be used as the cut-off point to indicate a good level of overall nutrition knowledge. Students with scores equal or more than this value were categorised as having 'good' and those with lower values as having a 'poor' level of nutrition knowledge. The choice of the highest percentile to indicate a good level of knowledge was based on previous findings suggesting that university students and graduates seem to be more health-conscious than no students (Georgiou et al., 1997) while a high number of participants was expected to study a health-related course, thus, they might had already some nutrition exposure via their courses.

The chi-square test was used to examine the significance of differences in the level of nutrition knowledge (poor versus good) in the various groups of students. The categorical variables used in the analysis were gender (male, female), BMI categories

(kg/m^2) (underweight, normal weight, overweight), age (18-25 years, > 25 years), field of study (healthcare, non-healthcare), studying status (undergraduate, postgraduate), living arrangement (merged to living with parents/carer/family versus other living arrangements), ethnic origin (White, Black/Asian/Mixed/Other), having a nutrition qualification (yes, no), being on a special diet (yes, no), perceived health rating (poor/fair, good, very good/excellent) and smoking status (no, yes).

Binary logistic regression analysis was performed to identify significant predictors of good nutrition knowledge (dependent variable). A stepwise forward variable selection was used to identify all independent variables with a significant bivariate crude association with the dependent variable. Prior nutrition qualification was excluded from the analysis as it interacted with the variable of 'field of study' while gender was included, despite no significant association was found in the stepwise forward selection process, as evidence suggests it is a predictor of nutrition knowledge. The final model included five independent variables (four categorical and one continuous).

Nutrition knowledge and diet quality

Linear regression analysis was performed initially in a sub-sample of the study population (n=86) for diet quality (score) as the response variable and overall nutrition knowledge (score) as the independent variable after controlling for gender, age, field of study, ethnicity and being on a special diet. Because overall nutrition knowledge (score) was not significantly associated with diet quality (score) (F-test=0.82, p=0.56), the collinearity of the variables of the different sections of knowledge was explored: dietary recommendations, nutrient sources of foods, healthy food choices and diet-disease relationships. Adding the four sub-sections of nutrition knowledge in the model showed that there was collinearity between dietary recommendations (collinearity tolerance=0.57, p=0.69) and nutrient sources of foods (collinearity tolerance=0.57, p=0.18). When the two variables were removed, there was not collinearity between knowledge of healthy food choices (collinearity tolerance=0.90, p=0.018) and knowledge of diet-disease relationships (collinearity tolerance=0.87, p=0.045). Therefore, the final model included knowledge of healthy food choices and knowledge of diet-disease relationships as the independent predictors and diet quality as the response variable, after controlling for gender, age, field of study, age, ethnicity, and being on a special diet.

5.5 Results

5.5.1 Socio-demographic and other characteristics of the sample population

Most students were female (69.6%), of white ethnic origin (60%), undergraduate (79.6%), and younger than 25 years (63.3%). From the total sample, 33.9% of students were from the Faculty of Health, Social Care and Education, 31.3% from the Faculty of Science, Engineering and Computing, 12% from the Faculty of Arts and Social Sciences, 6.8% from the Faculty of Art, Design and Architecture and 7.8% from the Faculty of Medicine/Biomedical Sciences. When comparing with the number of students enrolled at KU for the academic years 2016-2017 and 2017-2018 (Chapter 3, Table 3.1), the sample had a representative proportion of students from the Faculties of Science, Engineering and Computing and Arts and Social Sciences, a higher (two times) number of students from the Faculty of Health, Social Care and Education and a lower (half) number of students from the Faculties of Business and Law as well as Art, Design and Architecture. About one third of students (33%) were living with their family or sharing a house and one quarter of students (25%) were living in student accommodation. Very few students (8.6%) were living alone in a house or flat. When asked to rate their health, 41.8% of the students responded good and 30.7% responded poor/fair. Only 27.5% rated their health as very good or excellent. As expected, a small number of students had a nutrition qualification (7.9%) or were on a special diet (14.7%) and very few were smokers (12.2%). Students had a mean BMI of 24.2±5.4 kg/m^2, with the lowest value being 16.3 kg/m^2 and the highest being 55.2 kg/m^2. The majority of the students had a normal BMI (63.1%) and about one third (32.4%) belonged to the overweight/obese BMI category. The characteristics of the sample population are presented in Table 5.2.

Table 5. 2. Description of socio-demographic and other characteristics of the sample population

Variable		Number of participants (n)	Percentage of cohort (%)
Age (years)			
	18-25	119	63.3
	>25	69	36.7
	Mean±SD	25.7±8.1	min=18, max=60
Gender			
	Female	133	69.6
	Male	58	30.4
Ethnicity			
	White[a]	114	60.0
	Black[b]	24	12.6
	Asian[c]	41	21.6
	Mixed[d]	11	5.8
Studying status			
	Undergraduate	152	79.6
	Postgraduate/other	39	20.4
Faculty of study			
	Health, Social Care and Education	65	33.9
	Science, Engineering and Computing	60	31.3
	Arts and Social Sciences	23	12.0
	Business and Law	16	8.3
	Art, Design and Architecture	13	6.8
	Medicine/Biomedical Sciences	15	7.8
Living arrangement			
	With parent(s)/carer/family	62	33.2
	Sharing a house or flat	62	33.2
	Student accommodation	47	25.1
	Alone (in house/flat)	16	8.6
Having a nutrition qualification			
	No	176	92.1
	Yes	15	7.9
Perceived health rating			
	Poor/Fair	58	30.7
	Good	79	41.8
	Very Good/Excellent	52	27.5
Being on a special diet			
	No	162	85.3
	Yes	28	14.7
Being a smoker			
	No	166	87.8
	Yes	23	12.2
BMI (kg/m^2)			
	Underweight (<18.5)	8	4.5
	Normal (18.5-24.99)	113	63.1
	Overweight (≥25.0)	58	32.4
	Mean±SD	24.2±5.4	min=16.3, max=55.2

[a] White British, White Irish or other White background. [b] Black British, Black Caribbean, Black African or other Black background. [c] Indian, Pakistani, Bangladeshi, Chinese or other Asian background. [d] White and Black Caribbean, White and Black African, White and Asian or other mixed background.

5.5.2 Overall and sub-section scores of nutrition knowledge

Students had a mean overall nutrition knowledge score of 61.33 (SD=11.35) and an overall median score of 63 out of 88 points. With regards to the sub-sections of knowledge, students had a mean score of 12.85 (SD=2.43) and a median score of 13 out of 18 points on the section of dietary recommendations; a mean score of 24.17 (SD=4.94) and a median score of 25 out of 36 points on the section of nutrient sources of foods; a mean score of 9.69 (SD=2.51) and a median score of 10 out of 13 points on the section of healthy food choices and a mean score of 14.73 (SD=3.47) and a median score of 15 out of 21 points on the section of diet-disease relationships. Among the different sections, the lowest mean score of knowledge was found in the section related to nutrient sources of foods and the highest score in the section related to healthy food choices. The mean and median scores of each section and overall nutrition knowledge are presented in table 5.3.

Table 5. 3. Nutrition knowledge (mean and median scores) of participants

Nutrition Knowledge (maximum possible score)	**N** (number of participants)	**Mean** (SD)	**Median** (Q1, Q3)
Dietary recommendations (18)	249	12.85 (2.43)	13 (11, 17)
Nutrient sources of foods (36)	214	24.17 (4.94)	25 (21,28)
Healthy food choices (13)	205	9.69 (2.51)	10 (8, 12)
Diet-disease relationships (21)	193	14.73 (3.47)	15 (13, 17)
Overall nutrition knowledge (88)	201	61.33 (11.35)	63 (55, 70)

5.5.3 Knowledge on specific nutrition topics

An in-depth analysis of the nutrition knowledge questionnaire data showed that a low number of respondents (%) answered correctly all questions (n) in relation to fats and fatty foods (0.5%, n=10), salt (7.9%, n=8) and methods to maintain a healthy body weight or prevent weight gain (5.9%, n=10). Low levels of knowledge were also found for starchy foods (15.2%, n=6) as well as wholegrains and fibre (13.9%, n=8). Less than 50% of respondents answered correctly the questions related to fruit and vegetables (29.7%, n=5), dairy (28.4%, n=3), sugars (28.1%, n=7), protein (27%, n=6), alcohol (29.6%, n=1), energy (38.5%, n=1), food labelling (35.9%, n=4), cancer (49%, n=1) and BMI categories/body shape (23.4%, n=3). About half of respondents provided correct answers to the questions related to oily fish (54.3%, n=1), cooking methods (59.8%, n=2) and nutrition-related risk factors of heart diseases (57.2%, n=2) and type 2 diabetes (59.8%, n=2). Finally, approximately all respondents answered correctly the one question on water intake (92.3%) and the two questions on processed foods (73%). Internal consistency was found to be low (Cronbach's Alpha <0.7) for the questions in relation to fruit and vegetables, processed foods, dairy foods, fats and fatty foods, cooking methods, BMI/body shape, and heart diseases/raised blood cholesterol. The number (%) of respondents who provided correct answers to the above nutrition questions are presented in Figure 5.1.

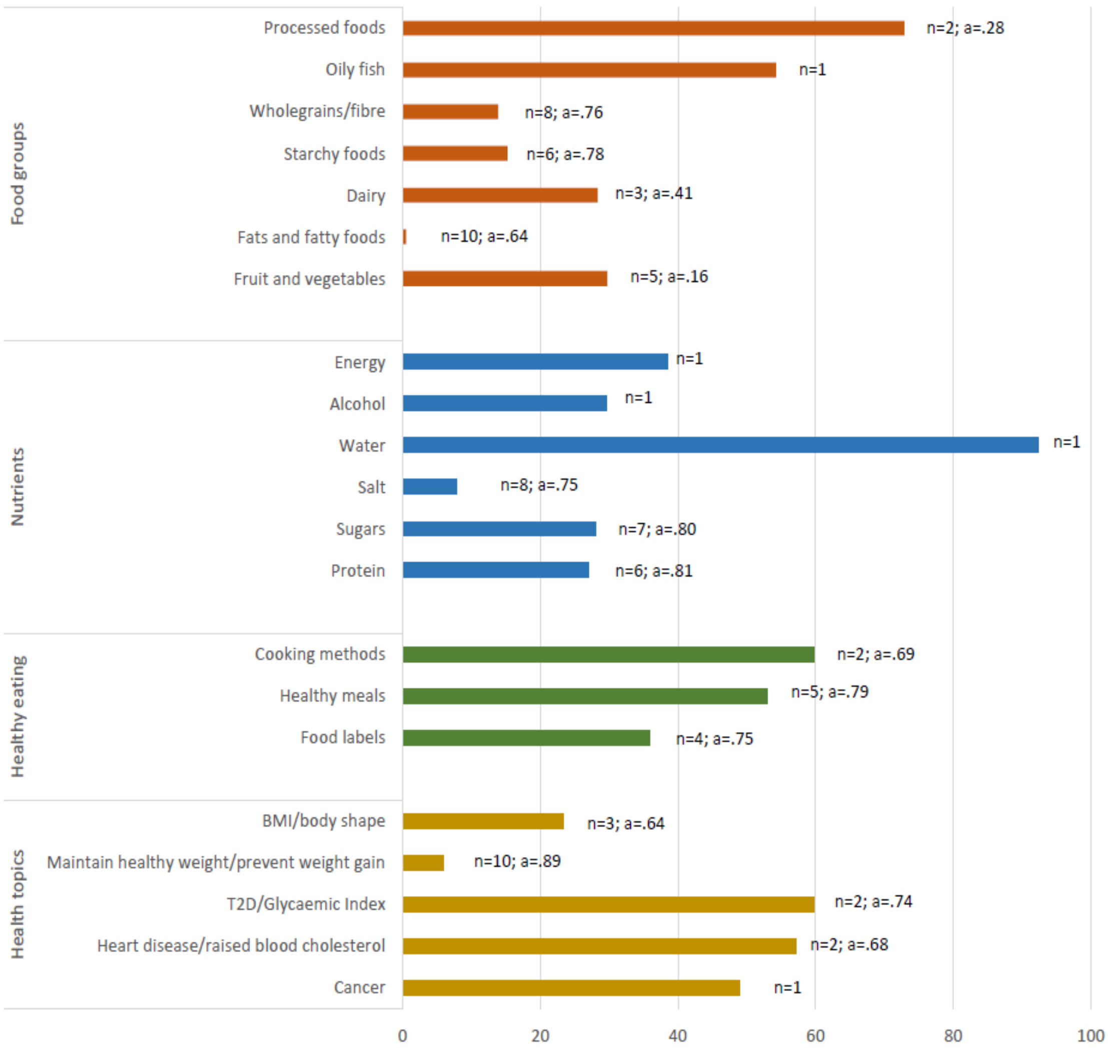


Figure 5. 1. Number of respondents (%) who provided correct answers on questions of the GNKQ-R addressing specific nutrition topics

Abbreviations used in the figure: n=number of questions, a=Cronbach's Alpha coefficient.

5.5.4 Nutrition knowledge in the various groups of students

Students from the healthcare field of study such as Medicine, Midwifery, Nursing and Paramedic Sciences had a significantly higher median score of overall nutrition knowledge compared to students from the non-healthcare field of study such as Business, Engineering and Law (median 66.5 versus 61.00, p=0.006). Similarly, students with a nutrition qualification had significantly higher scores than the unqualified ones (median 73.0 versus 63.0, p=0.014), student on a special diet (median 68.5 versus 63.0, p=0.038) as well as those of White ethnic origin compared to students of Black, Asian, Mixed or other ethnic origin (median 66.0 versus 58.0, p<0.001). Students who perceived their health as very good or excellent had also significantly higher median scores than those who rated their health as good, who in turn had higher scores than those who rated their health as poor/fair (median 68.0 versus 63.0 versus 60.0, p=0.001). No other significant differences in the median scores of overall nutrition knowledge were found in students according to gender, age category, BMI category, living arrangement, studying and smoking status (p>0.05). The differences in the median scores of overall nutrition knowledge in the various groups of students are presented in Table 5.4.

Table 5. 4. Nutrition knowledge (overall) median scores in the various groups of participants

Variable	GNKQ-R overall score		
	Median	Statistical test (degrees of freedom)	P-value
Gender			
Female (n=132)	64.00		
Male (n=58)	61.00	1.36 (1)	0.244
Age (years)			
18-25 (n=118)	62.00		
>25 (n=69)	65.00	0.86 (1)	0.355
BMI categories			
Underweight (n=8)	67.50		
Normal (n=112)	63.00		
Overweight (n=58)	64.50	0.94 (2)	0.624
Field of study [a]			
Non-healthcare (n=98)	61.00		
Healthcare (n=92)	66.50	7.58 (1)	**0.006***
Studying status			
Undergraduate (n=152)	64.00		
Postgraduate/other (n=38)	61.50	1.03 (1)	0.310
Living arrangements			
Living with parent(s)/carer/family (n=61)	63.00		
Living in student accommodation (n=47)	61.00		
Sharing a house/flat (n=62)	65.50		
Living alone (in house/flat) (n=16)	66.00	3.98 (3)	0.264
Ethnicity			
White (n=114)	66.00		
Black/Asian/Mixed/Other (n=75)	58.00	15.65 (1)	**0.000*****
Having a nutrition qualification			
No (n=175)	63.00		
Yes (n=15)	73.00	6.07 (1)	**0.014***
Being on a special diet			
No (n=161)	63.00		
Yes (n=28)	68.50	4.32 (1)	**0.038***
Perceived health rating			
Poor/Fair (n=58)	60.00		
Good (n=78)	63.00		
Very Good/ Excellent (n=52)	68.00	14.62 (2)	**0.001****
Being a smoker			
No (n=165)	64.00		
Yes (n=23)	57.00	0.45 (1)	0.504

[a] The Healthcare field included students from the Faculty of Health, Social Care and Education and the Medicine/Biomedical Sciences and those from other Faculties with a nutrition qualification. All other students were included in the non-healthcare field.

*p<0.05, **p<.005, ***p<.001

5.5.5 Participants with Good Nutrition Knowledge

About one quarter of students (26.4%) reached an overall nutrition knowledge score equal or higher than 70 points (75^{th} percentile cut-off point) that indicates a good level of nutrition knowledge. Significant differences were found between the level of knowledge (poor versus good) of students and their field of study (p=0.004), ethnicity (p=0.000), prior nutrition qualification (p=0.003), being on a special diet (p=0.049), and perceived health rating (p=0.002). Although the median scores of knowledge were significantly higher for students in the healthcare field, those of white ethnic origin, dieting and with a good/excellent perceived health rating compared to their counterparts, within each variable a higher number of students had poor rather than good nutrition knowledge (except students with a nutrition qualification). For example, students being on a special diet had significantly higher median knowledge scores than those not dieting, but within those dieting, only 42.9% demonstrated a good level of nutrition knowledge. Similarly, only 37% of students in the healthcare field, 38% of white ethnic origin, and 44% of students with a very good/excellent perceived health rating reached a good level of nutrition knowledge. The number of students with poor or good level of nutrition knowledge among the different groups of students is presented in Table 5.5.

Table 5. 5. Number of students with poor or good nutrition knowledge by sociodemographic and other categorical variables in the student population.

Variable (n, number of participants)	Poor nutrition knowledge	Good nutrition knowledge [a]	X^2	P-Value
	n (% within variable)	n (% within variable)		
Gender				
Female (n=132)	95 (72.0)	37 (28.0)		
Male (n=58)	43 (74.1)	15 (25.9)	0.91	0.758
BMI categories (kg/m²)				
<18.5 (n=8)	4 (50.0)	4 (50.0)		
18.5-24.9 (n=112)	80 (71.4)	32 (28.6)		
≥25.0 (n=58)	44 (75.9)	14 (24.1)	2.36	0.307
Age category (years)				
18-25 (n=118)	89 (75.4)	29 (24.6)		
>25 (n=69)	47 (68.1)	22 (31.9)	1.17	0.279
Field of study				
Non- healthcare (n=98)	80 (81.6)	18 (18.4)		
Healthcare (n=92)	58 (63.0)	34 (37.0)	8.25	**0.004****
Studying status				
Undergraduate (n=152)	109 (71.7)	43 (28.3)		
Postgraduate/other (n=38)	29 (76.3)	9 (23.7)	0.32	0.569
Living arrangement				
Parent(s)/carer/family (n=61)	47 (77.0)	14 (23.0)		
Other (n=125)	89 (71.2)	36 (28.8)	0.71	0.398
Ethnicity				
White (n=114)	71 (62.3)	43 (37.7)		
Black/Asian/Mixed/Other (n=75)	66 (88.0)	9 (12.0)	15.01	**0.000*****
Having a nutrition qualification				
No (n=175)	132 (75.4)	43 (24.6)		
Yes (n=15)	6 (40.0)	9 (60.0)	8.72	**0.003****
Being on a special diet				
No (n=161)	121 (75.2)	40 (24.8)		
Yes (n=28)	16 (57.1)	12 (42.9)	3.88	**0.049***
Perceived health rating				
Poor/Fair (n=58)	50 (86.2)	8 (13.8)		
Good (n=78)	57 (73.1)	21 (26.9)		
Very Good/Excellent (n=52)	29 (55.8)	23 (44.2)	12.73	**0.002****
Smoking status				
No (n=165)	117 (70.9)	48 (29.1)		
Yes (n=23)	19 (82.6)	4 (17.4)	1.38	0.240

[a] Good knowledge is defined as having an overall GNKQ-R score ≥ 70 points
*p<0.05, **p<.005, ***p<.001

5.5.6 Predictors of Good Nutrition Knowledge

The logistic regression analysis showed that age, perceived health rating, field of study and ethnic origin were significant predictors of good nutrition knowledge. No significant association was found between gender and nutrition knowledge ($p=0.657$). In particular, students in the healthcare field of study were 2.8 times more likely to have good nutrition knowledge compared to students in non-healthcare fields of study (Odds Ratio =2.76, 95% CI: 1.3-6.0, $p<0.05$). Students who perceived their health as very good or excellent were 4.6 times more likely to have good nutrition knowledge compared to students who perceived their health as poor or fair (Odds Ratio= 4.64, 95% CI: 1.7-12.7, $p<0.005$) while those with an ethnic background other than White were 82% less likely to have good nutrition knowledge (Odds Ratio=0.18, 95% CI: 0.07-0.4, $p<0.001$). An association, although weak, was found between age and knowledge, as one-year increment in age could increase the level of good nutrition knowledge by 5% (Odds Ratio= 1.05, 95% CI: 1.0-1.1, $p<0.05$). The overall model predicted 20.5% of the dependent variable (Model Summary $R^2=0.205$, $p<0.001$). The predictors of good nutrition knowledge, the Odds Ratio and 95% Confidence Intervals are presented in Table 5.6.

Table 5. 6. Predictors of good nutrition knowledge among university students (n=182)

Dependent variable	**Predictors**	**Odds ratio**	**95% Confidence Intervals**		***P*-value**
			Lower	Upper	
GOOD NUTRITION NOWLEDGE [a]	**Age** (years)	1.05	1.0	1.1	**0.035***
	Perceived health rating				
	Poor-Fair (RG)				
	Very Good/excellent	4.64	1.7	12.7	**0.003****
	Field of study				
	Non-healthcare (RG)				
	Healthcare	2.76	1.3	6.0	**0.011***
	Ethnic origin				
	White (RG)				
	Black/Asian/Mixed/Other	0.18	0.07	0.4	**0.000*****

RG: reference group

[a] The full model included age, perceived health rating, field of study, ethnic origin and gender.
*p<0.05, **p<0.005, ***p<0.001

5.5.7 Nutrition knowledge and diet quality

Linear regression analysis was performed for diet quality (score) as the response variable and the knowledge scores of healthy food choices and diet-disease relationships as the independent variables after controlling for gender, age, field of study, ethnicity, and being on a special diet. The models showed that an increase by 1-point of healthy food choices knowledge score was significantly associated with an increase in diet quality score by 0.29 points (β=0.29, 95% CI: 0.06-0.52, p=0.016) and an increase by 1-point of diet-disease relationships knowledge score was significantly associated with an increase of diet quality score by 0.20 points (β=0.20, 95% CI: 0.03-0.36, p=0.019). The model was statistically significant (F=2.44, p=0.026) and explained 11% of the variability observed in diet quality (Adjusted R^2=0.11). The regression analysis of diet quality and knowledge of healthy food choices and diet-diseases relationships is presented in Table 5.7.

Table 5. 7. Linear regression analysis of diet quality and knowledge of healthy food choices and diet-disease relationships in a sample of university students (n=86)[1]

Dependent variable	**Knowledge (predictors)**	**Unstandardized coefficients**			**Model**		
		Betas	95% CI	p-value	*F*-test	p-value	Adjusted R^2
Diet quality	Healthy food choices	0.29	0.06-0.52	0.016	2.44	0.026	0.11
	Diet-disease relationships	0.20	0.03-0.36	0.019			

[1]The dependent variable in model was diet quality (scores 0-16). Predictors were knowledge of healthy food choices (scores 0-13) and knowledge of diet-disease relationships (scores 0-21). Demographic and personal characteristics were used as control variables [gender (0: male, 1: female), age, field of study (0: healthcare, 1: non-healthcare), ethnicity (0: White, 1: non-White) and being on a special diet (0: No, 1: Yes)].

5.6 Discussion

5.6.1 Summary of findings of the study

5.6.1.1 Characteristics of the sample population

The current study aimed to investigate the level of nutrition knowledge, factors affecting knowledge and whether an increased knowledge is associated with improved diet quality in a sample of university students in the UK. The majority of participants were female (69.6%), of white ethnic origin (60%), undergraduate (79.6%), and younger than 25 years (63.3%) (Table 5.2) which is consistent with the findings of similar studies (Misra, 2007; Cooke & Papadaki, 2014), suggesting that specific groups of students might be more interested in participating in health-related surveys. Most students had a normal BMI, and about one third were overweight or obese, while very few students were underweight (4%). These numbers are consistent with those found in a large cross-sectional study in the US, where about one-third of students were overweight or obese (Misra, 2007). The study by Cooke & Papadaki (2014) in the UK found a slightly lower number of overweight and obese students (24%). Although the current study and the study by Cooke & Papadaki (2014) used self-reported measures of body weight and height, Cooke & Papadaki (2014) included a larger sample size (n=500) across 37 universities in the UK (outside the London area), which might explain the differences found in the prevalence of overweight and obesity. However, no other clinical or anthropometrical factors were assessed to provide a better estimate of students' health, while body weight and height were self-reported by students, with many chosen not to answer these questions or maybe not knowing these values. Overall students seemed to follow a healthy lifestyle in terms of not smoking and maintaining a healthy body weight and most of them regarded their health as good. Due to the specific characteristics of this population, it was expected that students in this study would be more aware of healthy nutrition. Existing evidence suggests that adults with an increased education level in the UK have higher levels of nutrition knowledge compared to those with lower or no qualifications (Parmenter & Wardle, 2000). Also, about half of participants (n= 98) were from a healthcare field of study, such as Midwifery, Nursing and Medicine, and were expected to have had some previous exposure on nutrition education during their courses.

5.6.1.2 Nutrition Knowledge of students

Students had a mean nutrition knowledge score of 69% of the total possible score, indicating a moderate level of overall knowledge (Table 5.3). These scores were very similar to the ones reported by Cooke & Papadaki (2014) in the UK (65.5%) and Kresić et al. (2009) in Croatia (67.4%), which also used the same questionnaire (old version) to assess knowledge. It is worth mentioning that the study by Cooke & Papadaki (2014) took place in 2013 while the current study took place from 2017 to 2018. Although, it is not clear to what extent the characteristics of the sample population of the two studies (field of study, geographical differences) affected overall nutrition knowledge, these findings suggest that the level of knowledge of students in the UK has not improved dramatically over the last 5 years.

When investigating the different areas of nutrition knowledge, this study found that students demonstrated a weak knowledge on nutrients. In particular, only 0.5%, 8% and 15% of participants answered correctly the questions related to fat, salt and dietary fibre respectively, indicating large gaps in knowledge for these nutrients (Figure 5.1). This lack of knowledge could further explain the findings of studies reporting that university students consume high amounts of fats (Chourdakis et al., 2011; García-Meseguer et al., 2014) and salt (Burke et al., 2009) and low amounts of dietary fibre (García-Meseguer et al., 2014). Insufficient knowledge was also found for sugars and protein with more than two thirds of participants providing wrong answers. Again, this could explain the findings of studies reporting that students consume high amounts of protein (animal) foods such as red meat (Yahia et al., 2016) as well as foods and drinks rich in added sugars, such as sweets (El Ansari et al., 2011) and sugar-sweetened beverages (Deliens et al., 2015b), without considering the negative implications of red meat (Satija et al., 2017) and sugary drinks (Barrio-Lopez et al., 2013) consumption on their health.

More than half of participants answered correctly the questions related to processed foods, oily fish, water intake and cooking methods. One should notice that the questionnaire included very few questions, with multiple choice answers, to address some nutrition topics (e.g. one question for oily fish and water intake, two questions for processed foods and cooking methods) increasing the chances of respondents to have chosen the correct answers by chance or by deducting the obvious incorrect choices (McAllister & Guidice, 2012). Despite this limitation, multiple-choice questions are regarded quick and easy tools to provide an estimate of knowledge of multiple areas (McAllister & Guidice, 2012).

With regards to knowledge of other nutrition aspects, only one third of respondents were aware that the recommended maximum intakes of alcohol were one drink per day both for men and women (Department of Health, 2016). This might be explained by the fact that alcohol recommendations were updated in 2016 and the recommended amount was reduced. Students in this study demonstrated a good level of knowledge regarding the intake of foods and their relation to diseases such as cancer, type 2 diabetes and cardiovascular diseases (median score 15 out of 21) compared to the one found in Cooke & Papadaki (2014) (median score 9 out of 20). This might be explained by the high number of participants in this study enrolled on health-related courses.

Regarding BMI categories, few students (23%) were aware of the cut-off points which might also explain the low knowledge found on optimal practices to maintain a healthy BMI. In particular, the majority of students (94%) were confused when asked about dietary practices to maintain a healthy body weight or prevent weight gain with some students answering that following a high protein diet, taking nutritional supplements or avoiding fat from diet are orthodox practices. Fads diets, which usually include the elimination of food groups from diet, are popular and common practices to lose weight, especially in females (Davy et al., 2006) and overweight young adults (Milosavljević et al., 2015) due to their 'promising' quick and easy outcomes. Trying to lose weight is a concern occupying not only overweight but also many students with a healthy body weight (Wharton et al., 2008). A study among 38,204 university students in the US, demonstrated that students (both genders) with false perceived body weight were more likely to engage in unorthodox weight loss practices, and only one third of those trying to lose weight did so by following a balanced diet and exercise (Wharton et al., 2008).

5.6.1.3 Predictors of Good Nutrition Knowledge

In the current study, about one quarter (26%) of students reached a good level of nutrition knowledge (score ≥70 points). Field of study, perceived health rating, ethnic origin and age were significant predictors of good nutrition knowledge (Table 5.6). Participants studying a healthcare discipline had significantly higher median scores than students from non-healthcare disciplines. These findings are consistent with other studies demonstrating that students from Theoretical and non-medical Practical Sciences had lower nutrition knowledge compared to students from Medical or other Health Sciences or those with a nutrition qualification (Jasti & Kovacs, 2010; Al -Naggar & Chen, 2011; Bottcher et al., 2017), justifying the initial speculation that students from a healthcare course had been somehow exposed and were more knowledgeable about good nutritional practices. However, within students from health-related courses, only

37% reached or exceeded the threshold of 70 points, which indicated good nutrition knowledge in the current study (Table 5.5). These findings suggest that, although these students seem to have greater knowledge when compared with their counterparts from non-health courses, still their knowledge is not adequate to reach a good level. Students who rated their health as very good or excellent were four times more likely to have good knowledge compared to students who rated having poor or fair health (Table 5.6). This implies that students with high nutrition knowledge feel healthier. These findings are in line with the study by Matthews et al. (2016) which found that students, particularly those from health sciences, felt more confident to claim that they have good knowledge of nutrition topics.

The study also found that students of White ethnic origin had higher levels of knowledge compared to students with Black, Asian or other Mixed ethnic backgrounds. This might be due to the different cultural and culinary traditions of the ethnic populations or the fact that non-UK students might not have adapted yet to their new environment and had not enough time to become familiar with the UK-based foods and dietary recommendations. What is further alarming is that even dietetic students seem not to be knowledgeable of the food habits and health beliefs of different ethnic groups, as reported in Mcarthur et al. (2011). These findings suggest that the cultural background of students might play an important role on their dietary knowledge and behaviour, which may be overlooked in current health-promoting strategies.

5.6.1.4 Nutrition knowledge and diet quality

In the current study, knowledge about healthy food choices and diet-disease relationships was positively associated with increased diet quality (Table 5.7), suggesting that health-promoting interventions might be more effective if they include more information and practical advice on these specific nutrition areas. However, the knowledge variables in this study were not strong predictors of diet quality as they explained only a small percentage of the variability observed in diet quality (Adjusted R^2=11%). These findings are consistent with those of Cooke & Papadaki (2014) in the UK, where nutrition knowledge was a positive but weak predictor of diet quality in students (Adjusted R^2=28%). This implies that other factors besides the ones included in the model might be strongest predictors of diet quality. As discussed in the **Overview** (Chapter 4, section 4.7.2.), the Theory of Planned Behaviour suggests that knowledge can indirectly impact behaviour by acting as a mediator of other constructs that strongly predict behaviour. For instance, a study in university students found that nutrition knowledge was significantly correlated with nutrition label use, which mediated the relationship between nutrition knowledge and diet quality (Cooke & Papadaki, 2014). Another study in students found that, although an increase in nutrition knowledge was associated with healthier eating, this relationship was significantly dependent by other predictors such as gender, studying status and place of eating (Kresić et al., 2009). As a result, nutrition knowledge seems to act as a mediator towards healthy eating by significantly affecting attitudes towards nutrition, which in turn have been found to predict healthy eating practices along with other factors (price of foods, taste, etc.) (Dahm et al., 2009; Barzegari et al., 2011).

5.6.2 Strengths and limitations of the study

Limitations of the study included the high drop-out rates, as 301 participants entered the study of which 249 participants provided consent and completed at least 20% of the questions. For the analysis, the maximum number of values per participant were used in order to not reduce the power of the sample, however, one could argue that there are other statistical approaches (e.g. data imputation) to handle missing data.

BMI was calculated based on self-reported data, providing less accurate values (underreporting) when compared with data assessed with objective methods (e.g. lab equipment) (Willet, 2012). As reported in the **Research Methods and Procedures** (Chapter 3, section 3.6.5) self-reported measures of BMI have a small effect on associations observed in epidemiological studies and can still provide important information (Willet, 2012).

To the best of our knowledge, this is the first study that used the updated version of the GNKQ questionnaire, allowing to explore the knowledge on recently updated nutritional information, such as oily fish, hidden sources of salt, alcohol intake, cooking methods, food labelling and optimal practices to maintain a healthy body weight. Besides Cooke & Papadaki (2014), who investigated nutrition knowledge as a predictor of food label use in a sample of university students in the UK, no similar studies have been conducted in the UK to investigate gaps in nutrition knowledge and factors affecting this knowledge in students. It should be noted thought that the GNKQ-R included only multiple-choice questions, which allowed students to have guessed the right answer or choose it by excluding the obvious wrong answer, as discussed earlier.

Also, the relationship between knowledge and diet quality was explored in this study, although only a small number of participants was used in the analysis, and a larger sample size would have provided safer conclusions. Students were recruited from two London-based universities, one of which provided only health-related scientific disciplines. This resulted in having a high number of students from healthcare courses which reduces the generalisability of our findings, although, concurrently, it provided the opportunity to explore the impact of the field of study on nutrition knowledge. It is important to note that both universities attract a high number of diverse students and students living outside the UK, which is very common for London-based universities and might explain the differences in knowledge found between the different ethnic groups. It may also imply that the lifestyle challenges and difficulties students face during the transition from high-school to university might be more intense for the students who just move to the UK for studying. However, these are speculations and are not addressed by this research.

5.6.3 Conclusion and future implications

Since the science of nutrition is multifaceted, there is a need for investigating in-depth which aspects of nutrition students are less knowledgeable about and need improvement, as increases in knowledge of specific nutrition areas might benefit students' dietary behaviour. Gaps in knowledge were found regarding the intake of fats and sodium as well as good practices of weight management which might negatively impact students' relevant behaviour. When assessing knowledge, using mixed-methods research design or enhance the quantitative data with open-ended questions might help to elaborate and get an in-depth understanding of students' knowledge. When investigating nutrition knowledge, researchers should consider the scientific discipline but also the different cultural and ethnic background of students, as this study found that students from a healthcare field of study and of White ethnic origin demonstrated higher levels of nutrition knowledge. However, even among students from a healthcare field of study, the majority did not manage to demonstrate a good level of nutrition knowledge, suggesting that nutrition education interventions should be applied to all students, irrespectively of their course. Finally, more research is needed to investigate the reliability and validity of the sources of information that students use to gain knowledge on nutrition and weight-management practices.

Chapter 6. The design, implementation and evaluation of a game-based e-programme to improve nutrition knowledge, diet quality and physical activity in university students in the UK

6.1 Overview of the chapter

As presented in Chapter 4, face-to-face and e-interventions found to have similar effect on dietary and physical activity behaviour in university students, with most interventions being non-randomised trials. The findings of Chapter 5 provided important information with regards to the current gaps in nutrition knowledge of students and concluded that an increased knowledge contributed to better measured diet quality. In this chapter, the implementation of a randomised controlled trial (RCT), aiming to explore the impact of a web-based educational programme with quiz-games (e-programme) on nutrition knowledge and weight-related behaviours (diet quality, physical activity), in a sample of university students in the UK are presented (objective 3 of the thesis). The rationale and development of the e-programme, including the pedagogical theories underpinning the design and content of the educational materials are presented as well as the methodology followed to assess the outcomes of interest. The changes in nutrition knowledge, diet quality and physical activity between the two groups (intervention versus control group) of the study are explored as well as whether the level of engagement with the e-programme had an impact on the outcome of interest. The data from students who engaged with the e-programme and played the online quiz-games was further analysed to explore the frequency of game-playing and performance of players as well as the time point where increased engagement with the games did not improve further the performance of players. Finally, the chapter presents the findings of a follow-up evaluation study among students who engaged with the e-programme to explore their perceptions regarding the content, feasibility, value and sustainability of the programme.

6.2 Introduction

Transition from high-school to university is associated with poor dietary habits and low levels of physical activity with subsequent weight gain in students (Deforche et al., 2015). The transition from adolescence to adulthood is an important period for establishing behavioural patterns that affect long-term health and risk of chronic diseases (Small et al., 2012). Young people use almost daily the internet for their own purposes but also to search for health information (Mo, 2012). Using the world wide web to implement health-promoting interventions has many advantages in terms of easiness, cost, accessibility, anonymity and social interaction (Mo, 2012). Since the findings of this **Overview** (Chapter 4) suggest that both face-to-face and e-interventions had the same (low) effect on dietary and physical activity behaviour, the development of an e-programme was regarded as a more favourable approach compared to a face-to-face intervention in order to improve health outcomes in university students. Of the 30 e-interventions identified in the overview process, only four used quizzes (Ornes & Ransdell, 2007; Grim et al., 2011; Green et al., 2012; Okazaki et al., 2014). In these studies, quizzes were used as auxiliary components to increase interest in the intervention (Green et al., 2012), enhance learning (Okazaki et al., 2014), input information (e.g. log goals and activities) (Ornes & Ransdell, 2007) and assess initial knowledge before accessing the main intervention (Grim et al., 2011). However, none of these studies used quiz-games as the main educational component or evaluated the impact of the quizzes on the outcomes of the study. In a study by Shaikh et al. (2017), online quizzes were the main component of the intervention to enhance knowledge on quality improvement, patient safety and care transitions among US university students. The authors concluded that quizzes were effective and acceptable in increasing knowledge but also allowed participants to apply skills by including questions about application of knowledge.

Gamification is the use of game-elements to traditional learning to enhance the learning experience and increase motivation and interest in playing the game (Deterding et al., 2011; Kapp, 2012). Using game-elements such as videos, challenge, goals, award and feedback seems to make the learning process more appealing, increases students' engagement and preserves knowledge for a longer period compared to traditional paper-based educational methods (Randel et al., 1992; Kapp, 2012). To our knowledge, only two studies used game-learning among university students. Huang et al. (2009) used virtual-rooms, learning by playing games and animations in first-year female students in Taiwan to increase their physical activity. However, the study had two experimental groups (tailored versus generic messages) against a control group, which both had access to the virtual rooms, making it difficult to conclude whether the increases in physical activity observed at the end of the study were caused by the gaming or the tailored approach. The study by Johnston et al. (2012) also used an alternative reality game, including point collection, to increase physical activity among first-year students in the US. The study found that students in the gaming group significantly increased their daily steps contrary to those in the control group, which decreased their steps. However, the game was not successful to increase moderate or vigorous levels of physical activity, most likely because the game emphasised in accumulating and log in steps to reach the game-goal. Both Huang et al. (2009) and Johnston et al. (2012) reported that games were well accepted by students. To our knowledge, no studies were identified that used quizzes with game-elements to improve dietary and physical activity behaviour in university students. Therefore, the current study aimed to develop an online intervention using quizzes with game-elements to improve nutrition knowledge, diet quality and physical activity in a sample of university students in the UK. The research questions of the current study are presented below.

6.3 Aim and research hypotheses of the study

The aim of the research was to investigate the impact of an e-programme using quiz-games on nutrition knowledge, diet quality and physical activity, in a sample of university students in the UK (**objective 3 of the thesis**). The study also explored whether adherence to the e-programme had an impact on nutrition knowledge of students.

To investigate the objectives, a series of hypotheses was generated and tested:

Hypothesis 1:

- H_1: The e-programme significantly improves the level of nutrition knowledge in university students.
- H_0: The e-programme has no impact on the level of nutrition knowledge in university students.

Hypothesis 2:

- H_2: The e-programme significantly improves diet quality and level of physical activity in university students.
- H_0: The e-programme has no impact on diet quality and level of physical activity in university students.

Hypothesis 3:

- H_3: Nutrition knowledge of students with a moderate/high adherence to e-programme is significantly higher compared to the knowledge of students with a low adherence to the e-programme or students in the control group.
- H_0: Nutrition knowledge of students with a moderate/high adherence to the e-programme does not differ from the knowledge of students with a low adherence to the e-programme or students in the control group.

In addition to the research objectives, the study explored which quiz-games were played by students, their performance as well as the impact of time (days) on performance when repeating a game. A follow-up evaluation study was also undertaken to explore the perceived value and feasibility of the intervention by students who were engaged with the programme.

6.4 Methods

6.4.1 Participants and recruitment process

To investigate the research hypotheses 1, 2 and 3, a single-blind RCT with two data collection points was used to address the research questions and test the hypotheses. The data collection points were at baseline and after a 10-week interventional period. The trial included two parallel groups, namely the intervention and the control group. Participants in the intervention group received access to the e-programme while the control group received no access to the e-programme or any other educational material. Students in the control group could ask permission to access the online materials on completion of the research project. Eligible students were those enrolled at the time of the study (2017-2018) at two London-based universities, aged 18 to 34 years, and free of any medical or other condition that required special treatment. A convenient sample of 88 participants was used for the purposes of this study and the voluntary nature of participation was emphasised. Students were recruited using posters, emails and intranet announcements using the campus and websites of the two universities. Once students made contact, an invitation letter with the participant information sheet were sent by email and after one-week, potential participants were contacted to inquire about their decision to participate. If they agreed to participate, students were further screened for their readiness to undertake a safe level of physical activity and whether at risk of eating disorders. Students at risk were excluded from the study. Participants were randomly assigned to one of the two groups but were aware of the existence of both groups. Students who completed the study received at the end a £10 Amazon voucher award. The study was approved by the Faculty Research Ethics Committee of Kingston University & St George's, University of London. A detailed description of the methodology of the RCT including the sample size calculation, eligibility criteria, recruitment and screening processes is presented in **Research Methods and Procedures** (Chapter 3, sections 3.5.1-3.5.4).

6.4.2 Rationale and development of the e-programme

The e-programme included a **website** and online **quiz-games**.

6.4.2.1 Website

A website was developed presenting fundamental information and practical advice about healthy eating and physical activity, reflecting students' dietary and exercise behaviour and gaps in nutrition knowledge according to the existing evidence in literature as presented earlier. The website also included the answers to the quiz-games as well as links to additional sources of information aiming to increase knowledge and facilitate favourable changes in behaviour. As presented in the **Literature Review**, university students seem to have low levels of physical activity (El Ansari et al., 2011) and consume high amounts of energy-dense foods (processed meat, sugary foods, fried and fast-food) and low amounts of healthy foods (e.g. fruit and vegetables, whole grain) (El Ansari et al., 2011; Yahia et al., 2016). Findings from the existing cross-sectional studies suggest that students have inadequate knowledge regarding food labelling, recommended servings of fruit and vegetables and wholegrain foods as well as the nutrients in foods and their role on health (Chapter 2, sections 2.6.2-2.6.6). Additionally, the cross-sectional study of the current research project (Chapter 5), found a lack of knowledge regarding fats, salt and practices to maintain a healthy body weight in students in the UK.

Based on the above evidence in addition to findings from qualitative studies investigating favourable nutrition topics within university students (Cousineau et al., 2006), a website including evidence-based information and practical advice related to healthy eating (Grundy et al., 2004; World Cancer Research Fund/ American Institute for Cancer Research, 2007; Public Health of England, 2016), eating on a budget (www.choosemyplate.gov/) and physical activity (Department of Health, 2011), was developed including the following health topics:

1) **Activity & Exercise**, 2) **Alcohol**, 3) **Body Weight**, 4) **Eating on a Budget**, 5) **Fast-food**, 6) **Fat**, 7) **Food Labels**, 8) **Fruit & Vegetables**, 9) **Meals & Snacks**, 10) **Meat**, 11) **Salt** and 12) **Sugars and Sugary Drinks**. Eating on a Budget included tips for saving money while shopping, Food labels included information about the content of a label and how to interpret it and Meals & Snacks provided ideas for healthy packed meals and snacks. The remaining topics included information about the relationship of each food group (e.g. fruits and vegetables) or physical activity with health and disease, definitions and terms often confused, tips and advice to improve eating and exercise behaviour as well as external links for further information. The topic of Body Weight included information on BMI categories, the implications of weight status with health and a BMI calculator. A summary of the website content is presented in Table 6.1. The full content of the website is available at: https://creativecontent.kingston.ac.uk/hsce-health/.

Table 6. 1. The summary of content and external links provided through the website

Health topics	Content of the website	External links
Activity and Exercise	Health benefits of exercise. Physical activity recommendations Tips to increase exercise and reduce sitting time.	Different types of activities. A 12-week physical activity plan to improve health.
Alcohol	Recommended intakes of alcohol. Health risks of overconsuming alcohol. Binge drinking. Tips to cut down alcohol.	Calculator of alcohol units. Tips to avoid weight gain from drinking alcohol.
Body weight	Importance of maintaining a healthy body weight. BMI categories and implications for health.	BMI calculator and interpretation of results.
Eating On a budget	Tips to plan a healthy diet without spending a lot of money. Tips for saving money while shopping for food.	Create a Grocery Game Plan. Shop Smart to Fill Your Cart. Prepare Healthy Meals.
Fast-Food	Definition of processed food and fast-food. Health risks of overconsuming processed food. Metabolic syndrome. Tips when eating at outlets.	More information on metabolic syndrome.
Fat	Energy content and role of fat in the body. Types of fat in the diet. Health implications of Saturated, Unsaturated and *Trans*-fat. Recommended intake of fat. Tips to cut down unhealthy fat and replace with healthier fat.	More information about the different type of fats, cholesterol and omega 3 and omega 6 fatty acids.
Food Labels	Information presented on a food label. Definition/Explanation of Reference Intake. Red, Amber, and Green colour coding on a label. Ingredients list on a label. Food shopping tips.	
Fruit & Vegetables (F & V)	Recommended Intake of F & V. What counts towards '5 a day'? Health benefits of eating 5 a day. What counts as a portion of F & V? Tips to increase F & V intake.	More information and examples on portion sizes. More ways to add F & V to daily meals (breakfast, lunch, dinner).
Meals & Snacks	The Eatwell Guide. Healthy packed lunches (ideas, etc) Breakfast (importance for health, ideas, etc) Snacks (ideas, etc).	More details on the Eatwell Guide. More ideas and recipes for healthy breakfast meals.
Meat	Health risks of eating a lot of processed meat and red meat. Foods belonging to red and processed meat. Recommended intakes of red and processed meat. Meat portions (raw, cooked). Tips to cut down red and processed meat. Tips to make healthier choices when buying	More information on meat (fat content, cooking methods, storing and freezing meat safely, meat alternatives, etc).

Health topics	Content of the website	External links
	meat.	
Salt	Recommended intake. Health implication of high salt intake. Food with high amounts of salt. Foods that might contain high amounts of salt. Tips to cut down salt.	More tips and recipes to reduce salt in diet. Tips to reduce salt when eating out.
Sugars & Sugary drinks	Added sugars/ sugary drinks- what's included. Health risks of eating/drinking too much sugars. Recommended intake of sugars. Nutrition labels and sugars. Tips to cut down on sugars. Sugary-free drinks. Tips to reduce intake of soft drinks.	More details on Glycaemic Index (GI) (definition, foods with a high, moderate and low GI). Top sources of added sugars in our diet. More tips to reduce sugars from meals.

6.4.2.2 Quiz-games

The Kahoot! Game-based learning platform was used to develop ten online quizzes (https://kahoot.com/). The platform is based on the learning theories of **Behaviourism**, **Instructionism**, **Constructivism** and **Gamification** and allows educators to create online quiz-games, free of charge. The theory of Behaviourism is based on the concept of 'stimulus-response', assuming that individuals learn and shape a behaviour based on the feedback they get from their previous experience (positive or negative) (Watson, 2013). Instructionism and Constructivism contribute to learning, with the first one characterised as teacher-centred, structured, non-interactive and driven by the outcomes (Engelmann & Carnine, 1991) and the second one as student-centred, process-driven and interactive with some instructions (Ernest, 1995). Gamification is the use of game-elements to traditional learning to enhance the learning experience and increase motivation and interest in playing the game (Deterding, et al., 2011; Kapp, 2012). Such game-elements include rewards (e.g. collecting points), time, collaboration or competition with others, feedback on performance and replay (Kapp, 2012). Time-restrictions increase concentration of learners and reduce loiter. Rewards provide stimuli to play the game repetitively to improve performance or achieve a goal. Collaboration or competition allows learning through social interaction. Instant feedback is formative and allows learners to get a sense of what they did wrong and how they could make it right. Finally, replaying allows learners to experience failure and provides the choice of playing again to learn through repetition and curiosity (Kapp, 2012).

For the purposes of this study, ten quiz-games were created, one for each topic presented on the website except of Body Weight and Eating on a Budget, as these were not part of the learning outcomes. Each game had ten multiple-choice questions, with a range of two to four answer options with only one correct response (see Appendix III). The theory of Instructionism was applied, as the quizzes were developed by the educator (PI), and those who played had to follow the game-instructions by answering the multiple-choice questions. In this study, students were not given the option to create their own quiz-games as this would affect the controlled conditions of the RCT, thus the theory of Constructivism was not applied. The intervention also used the Gamification theory, as the quizzes had the following game-elements: *time* - students had 30 seconds to answer each question; *reward* - students collected points and increased their score when choosing the right answer; *feedback*- right and wrong answers appeared at the end of the quiz-game; *social interaction*- students could collaborate or play against each other when playing the same game (invited by the same host); *replay*- students could repeat the quiz-game to improve their scores. According to Behaviourism theory, students faced the quiz-game (stimuli) and its multiple-choice questions (response). When students responded correctly, they received positive feedback and learnt by playing again. When students responded wrong, they received constructive feedback and learnt by not giving the same answer when playing again.

Students were encouraged to play as many times as they wished to improve their knowledge and scores and use the website as a reference tool to look for the correct answers. Features including music, videos and animated pictures where added to make the quiz-games more entertaining and engaging. Any electronic device was able to host the quiz-games and HTML i-frames were used to pinch the quiz-games to the website for easy access. Customised usernames and passwords were provided to students to access and play the games. Prior to the study, the quiz-games were piloted in a class of undergraduate nursing students to facilitate the time of response to each question and test the overall feasibility of the intervention (Figure 6.1).

***E*-mail messages** were sent twice per month to participants to provide feedback on their performance, to ask whether they faced any difficulties with the e-programme and to encourage them to continue playing and improve their scores.

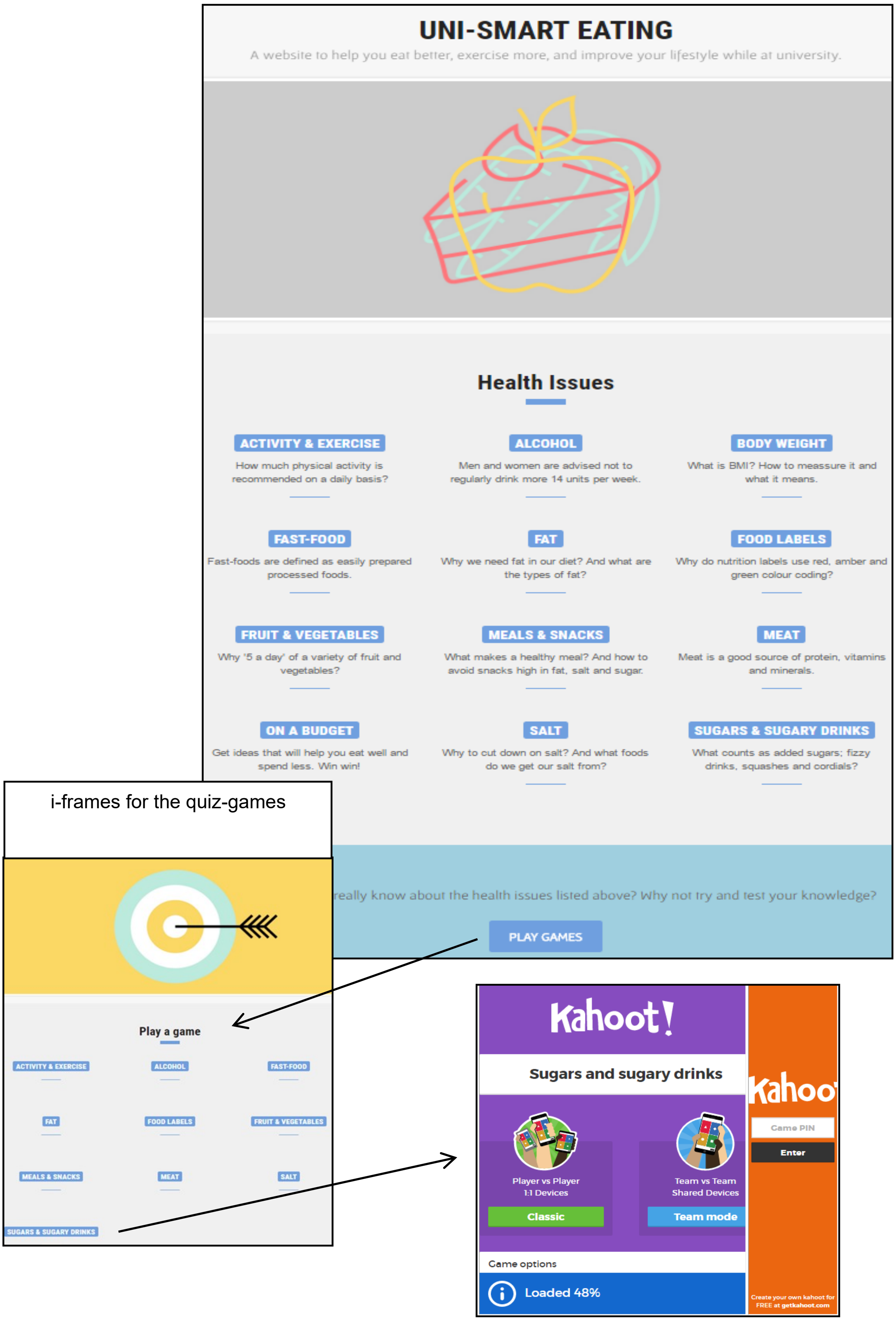


Figure 6. 1. The educational website with the attached i-frames for the quiz-games

6.4.3 Adherence to the e-programme

Students were asked to play at least one quiz-game once during the 10 weeks of the intervention (n=times playing a game). As the total number of quiz-games was 10, playing ten times (n=10) was considered as high engagement with the intervention. Therefore, the highest adherence level was set at 10 times. Dividing the 10-scale to three equal parts, 'n' ranged from 0 to 3 represented a low adherence rate; 'n' ranged from 4 to 6 represented a moderate adherence rate and 'n' ranged from 7 to 10 (or more) represented a high adherence rate. Because students were given the choice to play (or not) any quiz-game, as many times they wished, n (times playing) was calculated by adding the total number of games played, irrespectively whether it was the same or a different game.

6.4.4 Outcome measures

Nutrition knowledge, diet quality and physical activity were the main outcomes of the study. Self-reported validated questionnaires were used to assess the outcomes before and after the intervention in both groups.

Nutrition knowledge was assessed using the revised General Nutrition Knowledge Questionnaire (GNKQ-R) (Kliemann et al., 2016). The GNKQ-R is a validated tool, assessing four sections of nutrition knowledge, including dietary recommendations (18 items), nutrients in foods (36 items), healthy food choices (13 items), diet-disease relationships (21 items) and overall nutrition knowledge (sum of all sections, 88 items). Each correct answer got one point (otherwise null). More details regarding the GNKQ-R questionnaire are presented in **Research Methods and Procedures** (Chapter 3, section 3.6.2). In addition, the number of correct responses out of the total number of the questions (%) of each quiz-game was calculated among students who played the games, to assess their performance on each topic.

Diet quality was assessed using a validated semi-quantitative FFQ which calculates an Index of Diet Quality (IDQ) (Leppälä et al., 2010). The FFQ included 18 questions in relation to frequency and amount of intake of whole grain products, fat-containing foods, dairy products, vegetables and fruits, sugary foods and number of main meals skipped during the week. The IDQ score ranged from 0 to 15 points, with scores equal or less than 9 indicating a poor diet quality and scores equal or more than 10 indicating a high diet quality. More details regarding the IDQ questionnaire are presented in **Research Methods and Procedures** (Chapter 3, section 3.6.3).

Physical activity was assessed using the short form of the International Physical Activity Questionnaire (IPAQ-SF). The IPAQ-SF is a validated tool including questions about the frequency (days per week) and duration (minutes per day) of different types of activities (vigorous, moderate, walking) as well as sitting time (minutes per day). Based on the IPAQ-SF criteria described in Table 3.2 (Chapter 3), students were grouped to one of the following categories of physical activity: low, moderate and high. More details regarding the IPAQ-SF questionnaire are presented in **Research Methods and Procedures** (Chapter 3, section 3.6.4).

Demographic, **academic** and **personal characteristics** including age, gender, ethnic origin, field of study, residence status, current dieting practices, smoking status and acquired nutrition qualifications were collected at baseline as part of the GNKQ-R questionnaire.

Health indicators including body mass (kg), stature (m), body fat (%), waist circumference (cm), systolic and diastolic blood pressure (mmHg) and fasting blood glucose (mmol/l) were measured in the lab by the PI before and after the intervention. BMI (kg/m^2) was calculated from body mass (kg) and stature (m). As many students had an increased BMI but normal body fat levels (e.g. due to high muscle mass), a BMI/body fat (BMI/BF) index was calculated and the cut-off points are presented in Chapter 3, Table 3.2. More details regarding the assessment of the health indicators are presented in **Research Methods and Procedures** (Chapter 3, section 3.6.5).

6.4.5 Data analysis

Data was extracted from measurements and questionnaires and entered initially in Excel spreadsheets for cleaning and processing. All participants signed a consent form, so all data was included in the analyses. Regarding dietary habits, the average number was used for those who answered a range of portions (e.g. 1-2 slices of breads were converted to 1.5 slices of bread). Also, in questions related to the frequency (days per week) of consuming a food, no responses were found above 7, indicating that there were no outliers. Regarding physical activity, 5 participants responded, 'Do not know' and this data was removed from the analysis. No outliers were found for physical activity in this study (the scoring criteria and definition of outliers of IPAQ-SF are available at: www.ipaq.ki.se). IBM SPSS Statistics version 24 was used for the analysis of the data. The significance level was set at 0.05 for all tests.

6.4.5.1 Normality of data

The Shapiro-Wilk test was undertaken to test whether the main outcomes of the study followed a normal distribution. Regarding nutrition knowledge variables, overall nutrition knowledge (p=0.08) and knowledge of nutrients in foods (p=0.29) followed a normal distribution in contrast to knowledge of dietary recommendations (p=0.01) and knowledge of diet-disease relationships (p=0.006). Diet quality (IDQ) also followed a normal distribution (p=0.06). Physical activity was used in the analysis as categorical variable and grouped to low, moderate and high levels of physical activity. For the purposes of this study and due to a small sample size, low and moderate levels of physical activity were grouped together and compared against high levels of physical activity.

6.4.5.2 Baseline characteristics of the sample population

Descriptive statistics were used either as percentage of the sample population (%) or mean values and Standard Deviations (SD) to describe the demographic, academic, dietary, physical activity and health characteristics of the baseline population of the study. Chi-square tests (or the Fisher's exact test when the cells had expected counts less than 5) were used in the categorical variables and independent t-test for continuous variables to explore significant differences among the intervention and control group at baseline.

6.4.5.3 Analysis of research question 1: The e-programme significantly improves the level of nutrition knowledge in university students

An Intention to Treat (ITT) Analysis approach, as described in the **Research Methods and Procedures** (Chapter 3, section 3.7), was used to explore the differences in nutrition knowledge, diet quality and physical activity between participants in the intervention and control group over time. Generalised Estimating Equations (GEE) were used to explore the factors that influence the change in specific nutritional domains and overall knowledge outcomes. GEE is an appropriate estimating method for generalised linear models when there is correlation between the outcomes (before and after the intervention). The nutrition knowledge outcomes represent the number of 'successes' in the GNKQ-R questionnaire which in this study were 18 questions for section 1 (dietary recommendations), 36 questions for section 2 (nutrient sources of foods), 13 questions for section 3 (healthy food choices), 21 questions for section 4 (diet-disease relationships) and 88 questions for overall knowledge. 'Success' was defined as the correct answer in the corresponding questions. Thus, it was assumed that each of the knowledge variables followed a binomial distribution with 'n' independent trials (n = number of questions). The GEE models included the time-invariant factors: age, gender, field of study, ethnicity, and being on a special diet, the time-varying factor BMI/body fat index as well as the interaction of time with the groups of the study.

6.4.5.4 Analysis of research question 2: The e-programme significantly improves diet quality and level of physical activity in university students

Generalised Estimating Equations were used to explore the factors that affect diet quality and levels of physical activity in the study. Diet quality was considered a continuous outcome (score) following a normal distribution therefore GEE with linear response were used. Physical activity was considered a binary outcome (high level of physical activity versus low/moderate level of physical activity) therefore GEE with binary logistic response were used. The models included the time-invariant factors: age, gender, field of study and ethnicity, the time-varying factor BMI/body fat index as well as the interaction of time with the groups of the study. Participants being on a special diet (n=10) were excluded from the analysis of diet quality.

6.4.5.5 Analysis of research question 3: Adherence to the e-programme significantly affects nutrition knowledge of students

Per protocol analyses (i.e. drop outs were excluded from the analysis) were used to assess the effect of the level of adherence to the intervention on overall nutrition knowledge. Students in the intervention group were grouped to those with low adherence versus moderate/high adherence levels, using the cut-off points presented earlier. A mixed-design two-way repeated measures analysis of variance (ANOVA) was used to assess the effect of adherence level on nutrition knowledge (measured as GNKQ-R overall scores) between the following groups:

- Model A: Low-adherent versus moderate/high adherent participants in the intervention group and,

- Model B: Moderate/high adherent participants in the intervention group versus students in the control group.

To undertake ANOVA the following assumptions should be fulfilled a) normality, i.e. residuals must be normally distributed for each level of the independent variable, b) homoscedasticity, i.e. the variances on the dependent variables need to be the same for all the levels of the independent variables and c) independence of samples. In both models, the third assumption of independence was fulfilled as samples were unrelated. The assumption of normality was tested for the dependent variable (nutrition knowledge) before and after the intervention in both models using the Shapiro-Wilk and Kolmogorov-Smirnov tests and the criteria were fulfilled in all cases ($p>0.05$). In model

A, the assumption of homoscedasticity was tested using the Levene's test of Homogeneity of Variances for the dependent variable in each group of the study before and after the intervention and the criteria were fulfilled in all cases ($p>0.05$). Similarly, the Brown-Forsythe test was used to investigate the assumption of homoscedasticity in model B, and the criteria were fulfilled in all cases ($p>0.05$).

6.4.5.6 Analysis of the quiz-games

Descriptive statistics were used to present the number of participants who played each quiz-game, the number of times each game was played and the mean scores (% of correct answers) of each quiz-game. A further analysis was undertaken to explore whether the time period (days) between the first and second time playing a game affected the participants' performance (total score), among those who played the games twice. In particular, a Receiver Operating Characteristic (ROC) analysis was undertaken to estimate the cut-off point where the differences in scores ceased to improve. This cut-off point is the ceiling, meaning it is the time point (days) where engagement with the game (playing again) did not improve the performance (score).

6.4.5.7 Analysis of the follow-up evaluation study

After completing the study, participants were sent a questionnaire with closed- and open-ended questions asking them to indicate the extent at which they agree with various statements about the e-programme. Questions were grouped by the following domains: a) guidance and motivation to participate, b) characteristics of the programme (content, duration, mode of delivery, etc.), c) perceived impact of the e-programme on knowledge, d) accessibility and feasibility as well as e) value and sustainability of the programme (Appendix I.F). Eleven participants completed the evaluation study. Responses to the closed-ended questions were based on the following coding schemes:

- Disagree=1; somewhat disagree=2; somewhat agree=3; agree=4
- Not valuable=1; somehow valuable=2; valuable=3; very valuable=4
- No impact=1; minor impact=2; moderate impact=3; major impact=4.

The means and standard deviations (SD) were calculated based on the above coding scheme to obtain a clearer sense of participants' perceptions.

6.5 Results

6.5.1 Sample population characteristics

As shown in Figure 6.2, 150 students made contact and were assessed for their eligibility to participate in the study. Of these, 4 did not fulfil the eligibility criteria due to their age (older than 34 years) or had health condition issues, 30 declined to participate and 28 were unable to take part for other reasons such as lack of time or difficulties to commit to the study. As a result, 88 participants entered the study of which 50 were allocated to the intervention group and 38 to the control group. Seventeen participants from the intervention and 6 participants from the control group dropped out from the study for unknown reasons. As an ITT approach was used, the baseline data of the drop-out participants were used in the follow-up stage, resulting in data from 50 participants in the intervention group and 38 in the control group included in the final analysis.

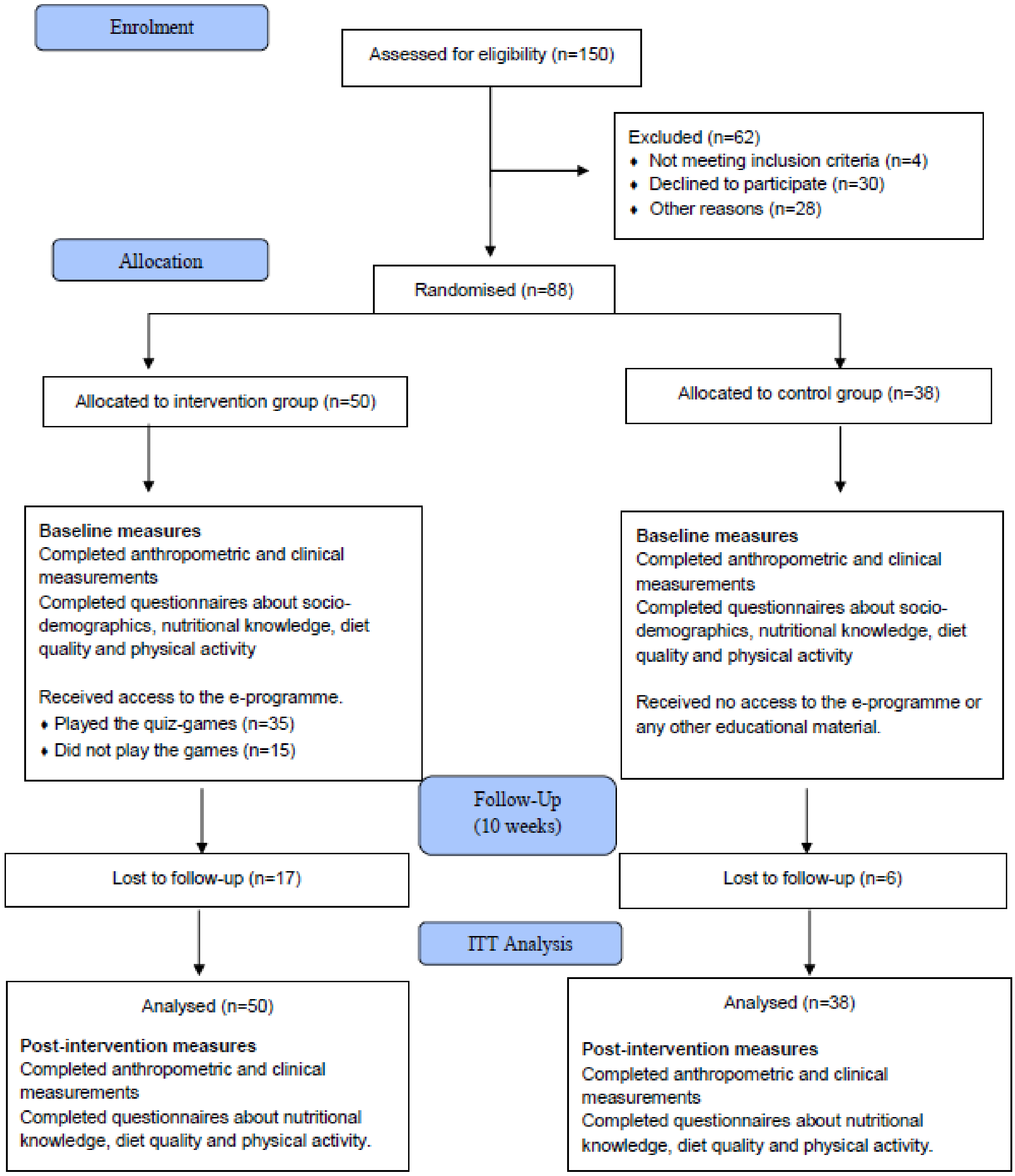


Figure 6. 2. Consort Flow Diagram of the RCT

The baseline characteristics of the sample population are presented in table 6.2. The majority of participants were female (67.0%), of White ethnic origin (59.8%) with mean age 23.01 years (SD=3.8). Regarding living arrangements, 41.9% of participants were sharing a house, 26.7% were living with their family, 25.6% where living in a student accommodation and only 5.8% were living alone in a house or flat at the time of the study. With regards to academic characteristics, 76.1% of participants were undergraduate students. When compared with the student profile of KU for the academic years 2016-2017 and 2017-2018 (Table 3.1), the study had a representative number of students from the Faculty of Health, Social Care and Education and the Faculty of Science, Engineering and Computing but a lower number of students from the remaining Faculties and the Faculty of Business and Law in particular. Also, 59.8% of participants were enrolled on non-healthcare courses.

Table 6. 2. Demographic and academic characteristics of the baseline population of the study (n=88)

Variables	n (%)
Gender	
Male	29 (33.0)
Female	59 (67.0)
Age (mean ± SD)	23.01 (3.8)
Living arrangement	
Parents/carer/family	23 (26.7)
Student accommodation	22 (25.6)
Sharing a house	36 (41.9)
Alone in house/flat	5 (5.8)
Ethnic origin	
White	52 (59.8)
Asian	21 (24.1)
Black	7 (8.0)
Mixed/other	7 (8.0)
Faculty	
Science, Engineering & Computing	38 (43.2)
Health, Social Care and Education	15 (17.0)
Arts & Social Sciences	11 (12.5)
Art, Design & Architecture	9 (10.2)
Business & Law	4 (4.5)
Medicine	7 (8.0)
Biomedical Sciences	4 (4.5)
Studying status	
Undergraduate	67 (76.1)
Postgraduate	21 (23.9)
Field of study [a]	
Healthcare	35 (40.2)
Non-Healthcare	52 (59.8)

[a] The healthcare field included students from the Faculty of Health, Social Care and Education and the Medicine/Biomedical Sciences and those from other Faculties with a nutrition qualification. All other students were included in the non-healthcare field of study.

The differences between the intervention and the control group of the study at baseline are shown in Table 6.3. No significant differences were found in age, gender, ethnic origin, living arrangement, nutrition knowledge, dietary and physical activity variables. However, a significantly higher number of participants in the control group completed the study compared to the intervention group ($p=0.05$). Also, even after randomisation more students from a non-healthcare faculty were assigned to the intervention group ($p=0.007$) as well as those with an unhealthy BMI/body fat index ($p=0.02$) compared to the control group.

Table 6. 3. Baseline differences in demographic, academic, dietary, physical activity and health factors between participants in the two groups (intervention and control) of the study

Variables	Control group (n=38)	Intervention group (n=50)	P-value
Completed the study, %			
No	6 (15.8)	17 (34.0)	**.05**
Yes	32 (84.2)	33 (66.0)	
Demographic and academic factors			
Age (years) (mean ± SD)	22.5 (3.3)	23.4 (4.1)	.28
Gender, %			
Male	15 (39.5)	14 (28.0)	.26
Female	23 (60.5)	36 (72.0)	
Ethnic origin, %			
White	25 (67.6)	27 (54.0)	.20
Black/ Asian/ Mixed/ Other	12 (32.4)	23 (46.0)	
Living arrangement, %			
Parents/carer/family or sharing a house	26 (72.2)	33 (66.0)	.54
Student accommodation or alone in house/flat	10 (27.8)	17 (34.0)	
Field of study, n (%)			
Healthcare	21 (56.8)	14 (28.0)	**.007**
Non-Healthcare	16 (43.2)	36 (72.0)	
Lifestyle habits			
Nutrition Knowledge (max. score 88)			
Overall score (mean ± SD)	64.0 (9.8)	63.7 (7.9)	.87
Diet quality (max. 15)			
IDQ Score (mean ± SD)	8.0 (2.4)	8.2 (2.0)	.70
Being on a special diet, %			
No	86.1	90.0	.74
Yes	13.9	10.0	
Physical activity, %			
Low/ Moderate	53.1	50.0	.79
High	46.9	50.0	
Sitting time			
Minutes per day (mean ± SD)	450.0 (193.1)	401.0 (122.4)	.21
Health indicators			
BMI category [a], %			
Underweight/ normal	73.7	60.0	.18
Overweight/ obese	26.3	40.0	
BMI/Body fat index [b], %			

Variables	Control group (n=38)	Intervention group (n=50)	P-value
Healthy	86.8	64.0	**.02**
Unhealthy	13.2	36.0	
Waist circumference [c], %			
Low risk	86.8	78.0	.29
High risk	13.2	22.0	
Systolic and diastolic blood pressure [d], %			
Normal values	73.7	70.0	.70
Elevated values	26.3	30.0	
Fasted blood glucose (mmol/L) [e] (mean ± SD)	4.9 (0.4)	4.8 (0.5)	.87

[a] Underweight/normal: BMI ≤ 24.9 kg/m^2 Overweight/ Obese: BMI ≥ 25.0 kg/m^2

[b] The Healthy BMI/BF index includes those with a BMI ≤ 24.9 kg/m^2 and healthy BF (%) or those with a BMI ≥ 25.0 kg/m^2 and healthy BF (%) for their gender. The Unhealthy BMI/BF index includes those with a BMI≥ 25.0 kg/m^2 and high BF (%) or those with BMI ≤ 24.9 kg/m^2 and high BF (%) for their gender. Body fat (%) ≤33% for female and ≤20 for male indicate normal values for the age category of 18-34 years.

[c] WC >94 for males and WC>80 cm for females indicates increased metabolic risk

[d] Blood pressure levels <120/80 mmHg are classified as normal.

[e] Fasting blood glucose values between 4.0 and 5.4 mmol/l are classified as normal.

6.5.2 The impact of the e-programme on nutrition knowledge

GEE models were used to identify the factors that affect the change in specific nutritional domains and overall nutrition knowledge. As shown in Table 6.4, significant differences were found between the two groups, with students in the intervention group having 38% higher chances of 'success' in the knowledge of dietary recommendations (where success is defined as the number of correct answers) compared to the corresponding chances of the control group (Odds Ratio=1.38, 95% CI: 1.08-1.77, $p<0.01$). Students of both groups had 33% higher likelihood of having better knowledge in diet-disease relationships (Odds Ratio=1.33, 95% CI: 1.14-1.55, $p<0.001$) and 14% higher likelihood of having better overall nutrition knowledge (Odds Ratio=1.14, 95% CI 1.03-1.28, $p<0.05$) after the intervention compared to their likelihood at baseline. However, no significant differences were found between the two groups over time, indicating that there is not enough evidence to conclude that the intervention had an impact on nutrition knowledge outcomes in this study. The above findings indicate that the intervention group had higher knowledge of dietary recommendations compared to the control group while both groups had significantly higher knowledge of diet-disease relationships and overall nutrition knowledge at the end of the study compared to baseline. However, the intervention was not effective to improve nutrition knowledge in students.

Field of study, **ethnicity**, **gender** and **BMI/Body Fat index** were factors associated with overall or specific domains of nutrition knowledge in students. In particular, students from a healthcare field of study had higher likelihood of giving correct answers on the questions addressing dietary recommendations (Odds Ratio=1.81, 95% CI: 1.40-2.34, $p<0.001$) or nutrient sources of foods (Odds Ratio=1.60, 95% CI: 1.23-2.10, $p<0.001$) as well as all questions (Odds Ratio=1.50, 95% CI: 1.22-1.86, $p<0.001$) compared to the corresponding likelihood of students from a non-healthcare field of study. Students of White ethnic origin had a higher likelihood of giving correct answers on questions addressing dietary recommendations (Odds Ratio=1.51, 95% CI: 1.10-1.92, $p<0.01$), nutrient sources of foods (Odds Ratio=1.37, 95% CI: 1.08-1.74, $p<0.01$) and diet-disease relationships (Odds Ratio=1.45, 95% CI: 1.10-1.94, $p<0.01$) as well as all questions (Odds Ratio=1.50, 95% CI: 1.21-1.86, $p<0.001$) compared to the corresponding likelihood of students from other ethnic groups (Black, Asian, Mixed or other ethnic background). Female students had higher odds of having better knowledge on healthy food choices (Odds Ratio=1.61, 95% CI: 1.14-2.27, $p<0.01$) compared to the odds of male students as well as those with a healthy BMI/Body fat index (Odds Ratio= 1.47, 95% CI 1.06-2.04, $p<0.05$) compared to the odds of those with an unhealthy index, with the same group of students having also higher odds of a better overall nutrition knowledge (Odds Ratio=1.26, 95% CI: 1.02 -1.56, $p<0.05$). The above findings indicate that studying a healthcare course, being of White ethnic origin, being female or having a healthy body composition was significantly associated with increased levels of overall nutrition knowledge or knowledge of specific nutrition domains.

Table 6. 4. The effect (odds ratio) of the intervention on nutrition knowledge outcomes (scores) and other factors associated with the dependent variables in the sample of the study (n=86, 2 missing)

Knowledge Outcomes (dependent variables)	**Dietary recommendations** (max score 18)		**Nutrient sources of foods** (max score 36)		**Healthy food choices** (max score 13)		**Diet-disease relationships** (max score 21)		**Overall knowledge** (max score 88)	
Predictors	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Time X group	1.08	0.86-1.34	1.17	0.97-1.41	0.81	0.50-1.33	0.85	0.69-1.03	1.02	0.89-1.17
Group: intervention (ref. category: control)	**1.38****	1.08-1.77	0.99	0.77-1.28	1.22	0.85-1.78	1.30	0.95-1.78	1.17	0.95-1.45
Time: post-intervention (ref. category: pre-intervention)	1.05	0.89-1.24	1.10	0.97-1.25	1.32	0.86-2.02	**1.33*****	1.14-1.55	**1.14***	1.03-1.28
Field of study: healthcare (ref. category: nonhealthcare)	**1.81*****	1.40-2.34	**1.60*****	1.23-2.10	0.76	0.54-1.08	1.30	0.99-1.72	**1.50*****	1.22-1.86
Ethnic origin: White (ref. category: non-White)	**1.51****	1.18-1.94	**1.37****	1.08-1.74	1.13	0.80-1.60	**1.45****	1.10-1.92	**1.50*****	1.21-1.86
Age (years)	1.00	0.98-1.03	1.02	0.99-1.05	1.01	0.97-1.06	1.03	0.99-1.07	1.02	1.00-1.04
Gender: female (ref. category: male)	1.03	0.81-1.30	0.84	0.66-1.07	**1.61****	1.14-2.27	1.10	0.83-1.45	1.00	0.81-1.24
BMI/Body Fat index: healthy (ref. category: unhealthy)	1.24	0.97-1.58	1.19	0.94-1.51	**1.47***	1.06-2.04	1.30	0.97-1.74	**1.26***	1.02-1.56
Being on a special diet: yes (ref. category: no)	0.96	0.74-1.23	0.98	0.73-1.36	0.77	0.48-1.26	1.05	0.73-1.50	0.98	0.78-1.23

*p<.05, **p<.01, ***p<.001

6.5.3 The impact of the e-programme on diet quality and level of physical activity

GEE models were used to explore the factors that affect diet quality (analysed as IDQ score) and level of physical activity in the two groups. As shown in Table 6.5, no significant differences were found within or between groups or before and after the intervention, indicating that there is not sufficient evidence to conclude that the intervention had an impact on diet quality and physical activity level in this study.

Field of study and **BMI/Body Fat index** were the only factors associated with **diet quality** while **gender and BMI/Body Fat index** were the only parameters associated with **physical activity** in this study. Regarding diet quality, students from a healthcare field had significantly higher expected value of IDQ score by 0.83 ($\beta=0.83$, 95% CI: 0.08-1.58, $p<0.05$) than students from a non-healthcare field and those with a healthy BMI/Body Fat index by 0.89 ($\beta=0.89$, 95% CI: 0.15-1.62, $p<0.05$) than those with an unhealthy index, when all other parameters in the model remained constant. Regarding physical activity, females had significantly lower likelihood of undertaking high levels of activity compared to the corresponding likelihood of males (Odds Ratio=0.15, 95% CI: 0.05-0.48, $p<0.01$) while those with a healthy BMI/Body Fat index were 3.54 times more likely of being highly physically active compared to their counterparts with an unhealthy BMI/Body Fat index (Odds Ratio=3.54, 95% CI: 1.43-8.71, $p<0.01$), when adjusting for all the other factors in the model. These findings indicate that studying a healthcare course or having a healthy body composition was significantly associated with improved diet, and respectively, being male or having a healthy body composition was significantly associated with high levels of physical activity.

Table 6. 5. The effect of the intervention on diet quality (n=77) and level of physical activity (n= 83) and other factors associated with the dependent variables in the participants of the study

Lifestyle outcomes (dependent variables)	**Index Diet Quality score**		**High level of physical activity** (reference category: low/moderate)	
Predictors	Beta coefficient (β)	95% CI	Odds Ratio	95% CI
Time x group	0.27	-1.05-1.59	1.02	0.40-2.62
Group: intervention (ref. category: control)	0.55	-0.46-1.55	3.21	1.09-9.47
Time: **post-intervention** (ref. category: pre-intervention)	-0.02	-1.03-0.98	1.66	0.74-3.72
Field of study: healthcare (ref. category: nonhealthcare)	**0.83***	0.08-1.58	2.41	0.92-6.31
Ethnic origin: White (ref. category: non-White)	0.42	-0.25-1.10	1.70	0.72-4.02
Age (years)	-0.06	-0.15-0.03	0.94	0.74-3.72
Gender: female (ref. category: male)	0.14	-0.59-0.87	**0.15****	0.05-0.48
BMI/Body Fat index: healthy (ref. category: unhealthy)	**0.89***	0.15-1.62	**3.54****	1.43-8.71

*p<.05, **p<.01, ***p<.001

6.5.4 The effect of adherence to the e-programme on nutrition knowledge

A mixed-design two-way repeated measures analysis of variance (ANOVA) was used to assess the effect of adherence on nutrition knowledge (measured as GNKQ-R overall scores) between the various groups of the study following a per protocol analysis. As shown in Table 6.6, no significant differences in overall GNKQ-R scores were found after the intervention between participants with low versus moderate/high adherence in the intervention group (difference in scores=-1.4, partial η^2= 0.025, p=0.38) or between participants in the control group versus moderate/high adherent participants in the intervention group (differences in scores=1.8, partial η^2= 0.026, p=0.25), indicating that even those students who were engaged with the e-programme did not improve their scores of nutrition knowledge in this study.

Table 6. 6. Differences in mean scores, p-values and effect size for nutrition knowledge scores between low and moderate/high adherent students in the intervention group and between students in the control group and those with a moderate/high adherence in the intervention group

	Post-intervention					
	Low (n=12) versus moderate/high adherents (n=21)			Control group (n= 32) versus moderate/high adherents (n=21)		
Nutrition Knowledge	Difference in scores	Partial η^2	p-value	Difference in scores	Partial η^2	p-value
GNKQ-R overall score	-1.4	.025	.383	1.8	.026	.247

6.5.5 Results of the quiz-games

6.5.5.1 Players of the quiz-games and their performance

The e-programme included 10 quiz-games. Of the 50 participants in the intervention group, 15 did not play any game, meaning that 35 students were engaged to some extent with the quiz-games. On average, students played 6 out of 10 games with the Activity game being the most popular, as it was played by almost all participants (n=34) (Figure 6.3). The games of Fast-food and Alcohol were also played by a high number of students (n=24) followed by the games of Meals & Snacks (n=20), Fat (n=19) and Sugars (n=19) while Salt was the game played by the lowest number of participants (n=16).

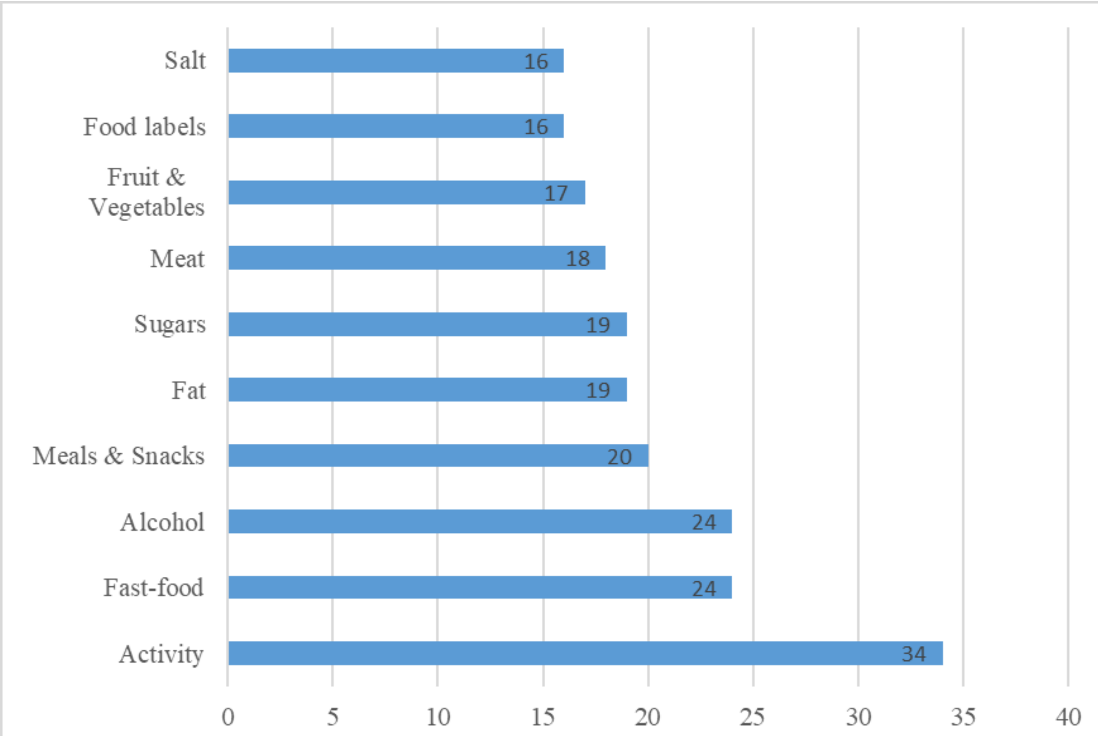


Figure 6. 3. Number of participants in the intervention group (n) that played each game (n total=35)

Among the 35 game-players, 15 played at least one game. In total, Activity was played 43 times, Fast-food was played 30 times, Alcohol was played 27 times, Fat was played 25 times, Meals & Snacks and Meat were played 24 times each, Salt was played 23 times, Sugars was played 21 times while Food labels and Fruit & Vegetables were played 17 times each (Figure 6.4).

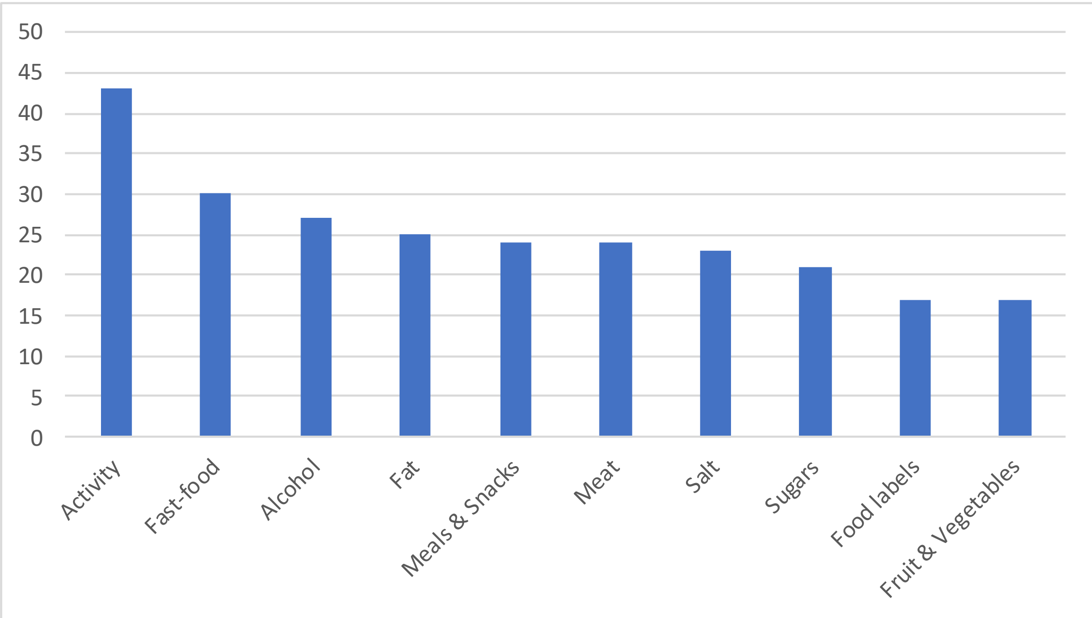


Figure 6. 4. Number of times the games were played by participants in the intervention group who played at least one game (n=35)

Each quiz-game had ten multiple-choice questions but there was only one correct answer per question. The game-players achieved a good score at Activity game by answering 77.5% of the questions correctly and the Fast-food game by answering correctly 76.7% of the questions (Figure 6.5). The average scores (% of correct answers) in the games of Fat, Meat, Fruit & Vegetables, Fast-food, Sugars and Alcohol, ranged from 62.3 to 71.5%. Salt was the game with the lowest average number of correct answers, namely 54.7%.

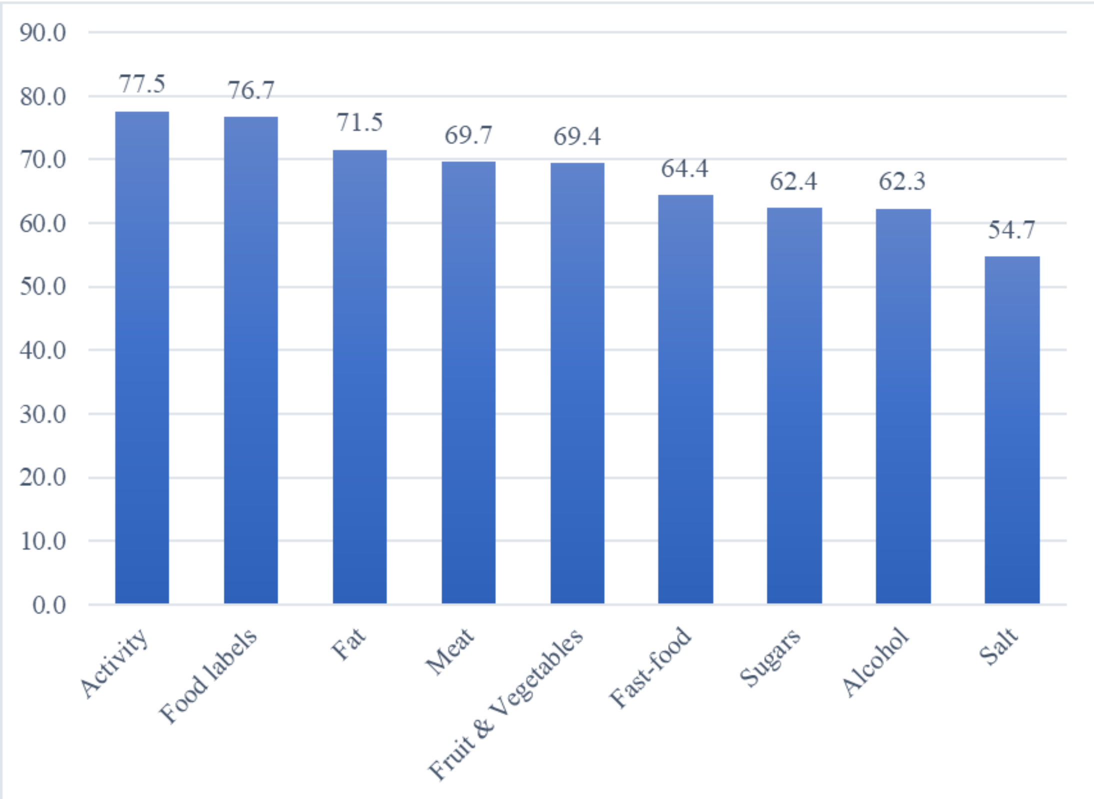
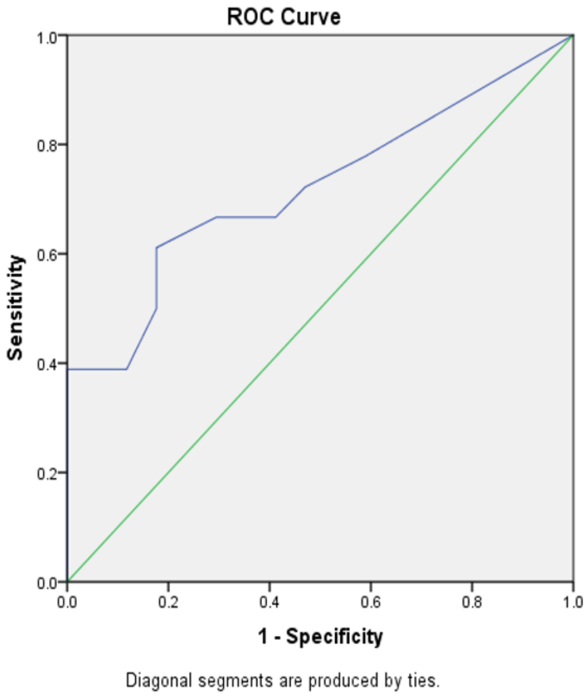


Figure 6. 5. Mean scores (% of correct answers) of quiz-games of participants in the intervention group who played at least one game (n=35)

6.5.5.2 The effect of time (days) on performance after repeating a quiz-game

In total, 35 quiz-games were played twice, 6 quiz-games were played three times, one quiz-game was played four times and one quiz-game was played fifth times. Only the quiz-games which were played twice were used in the analysis because very few participants played a quiz-game more than twice. The change in scores (score at second time minus score at first time point) was converted to a new binary variable. When the second score was higher the variable was coded as 'positive'. When the second score was lower or remained the same, the variable was coded as 'negative'. Based on this coding scheme, 18 students had a 'negative' change in scores and their average number of days before repeating the quiz-game was 21.2 (SD=21.3) while 17 students had a 'positive' change in scores and their average number of days before repeating the quiz-game was 5.9 (SD=9.3).

The ROC analysis demonstrating the ceiling (i.e. the cut-off point of days, when it was expected that after these days the score would not be improved if a player repeated the quiz-game) showed that the area under the curve was 0.72 (p=0.026), which represents a fair accuracy of the test to separate negative from positive changes in scores. From the findings of the ROC curve (Figure 6.6), it seems that 8 days was the cut-off point with the higher sensitivity or true positive rate (0.67) and lower false positive rate (0.29). According to the ROC analysis, when participants played a quiz-game for the second time within 8 days, their performance (score) improved, while after that point their performance remained the same or decreased.



Coordinates of the Curve

Test Result Variable(s): T2-T1 in days

Positive if Greater Than or Equal To[a]	Sensitivity	1 - Specificity
-1.00	1.000	1.000
.50	.778	.588
1.50	.722	.471
3.50	.667	.412
5.50	.667	.353
7.50	.667	.294
9.50	.611	.176
11.00	.556	.176
13.50	.500	.176
17.00	.389	.118
26.50	.389	.059
35.00	.389	.000
38.00	.333	.000
42.50	.222	.000
56.00	.056	.000
68.00	.000	.000

Figure 6. 6. ROC curve showing the accuracy of the test to estimate the cut-off point for the number of days where it is expected that when a player repeated the quiz-game after these days the score would not be improved. The cut-off point of 8 (days) seems to have the optimal sensitivity and 1-specificity in this test.

6.5.6 Findings of the Evaluation study

6.5.6.1 Perceived motive to take part in the study

Eleven students from the intervention group completed the evaluation study. Participants reported being motivated (n=5) or very motivated (n=6) at the start of the study. When asked about the main reason for participation, students reported curiosity, interest in healthy eating and lifestyle and contributing to fellow students' research projects as presented in table 6.7.

Table 6. 7. The written responses of students when asked the main reason for taking part in the study

Main reason	Responses of students
Curiosity	Wanted to get involved, help and see what the study implied
	A friend told me about it and it sounded interesting
Interest in nutrition and healthy lifestyle	My interest in nutrition and i felt i could learn something
	To know more about nutritional value and healthy eating
Help other students with their studies	I was interested in helping with a study
	I wanted to help others to proceed with their projects by volunteering to be a participant
Both reasons 3 & 4	Interest in the area and I wanted to help in the PhD
	I like to help out in surveys. I'm also interested in having a more healthy lifestyle

6.5.6.2 Perceptions regarding the content of the e-programme

Participants were asked to indicate the extent to which they agree with various statements about the **usefulness** of the anthropometric and clinical measures undertaken during the study and the topics included on the website and the quiz-games. Participants' answers are presented in Table 6.8. All (11/11) participants agreed that measuring body composition was very informative and almost all (9/11) reported that measuring blood pressure and blood glucose was helpful to learn about their health status (mean score=3.82). Students were given pedometers to count their steps for one week and the majority (8/11) reported that pedometers helped getting an estimate of their walking activity. The range of mean scores for the questionnaire items (3.64-4.00) suggest that students agreed about including information for all topics with Body Weight, Meat, Alcohol, Fast-food, Fats, Food labels, Fruit & Vegetables and Salt being the most highly rated ones (mean score $\geq$ 3.82). When asked for additional measures and topics they might have liked to be included in the e-programme, students reported assessment of fitness indicators such as heart rate (n=2), psychological measures (n=1) or additional clinical tests (e.g. cholesterol) (n=1). Regarding topics, some students reported they would have liked information on micronutrients (n=2), processed foods (n=1) and food intolerances (n=1) to be included. Also, they were asked which components (website, quiz-game, both) of the e-programme they preferred. Five students reported the quiz-game, two the website and three both components.

Table 6. 8. Perceptions of participants on the usefulness of measures undertaken and topics addressed in the e-programme

	n	Disagree	Somewhat disagree	Somewhat agree	Agree	Means (SD)*
Anthropometric and biochemical measures						
Measuring body composition (weight, fat, lean mass, etc.) was helpful to learn about my health	11	0	0	0	11	4.00 (0.00)
Measuring blood pressure or/and blood glucose was helpful to learn about my health	11	0	0	2	9	3.82 (0.41)
Counting steps was helpful to realize how much I walk	11	0	0	3	8	3.73 (0.47)
Topics chosen to be included in the educational programme						
I liked that information about **activity and exercise** was included	10	0	0	3	7	3.70 (0.48)
I liked that information about **alcohol** was included	11	0	0	2	9	3.82 (0.41)
I liked that information about **fast-food** was included	11	0	0	2	9	3.82 (0.41)
I liked that information about **fats** was included	11	0	0	2	9	3.82 (0.41)
I liked that information about **food labels** was included	11	0	0	2	9	3.82 (0.41)
I liked that information about **fruit and vegetables** was included	11	0	0	2	9	3.82 (0.41)
I liked that information about **meals and snacks** was included	11	0	0	3	8	3.73 (0.47)
I liked that information about **meat** was included	10	0	0	1	9	3.90 (0.32)
I liked that information about **salt** was included	11	0	0	2	9	3.82 (0.41)
I liked that information about **sugars, and sugary drinks** was included	11	0	0	3	8	3.73 (0.47)
I liked that information about how to **eat on a budget** was included	11	0	0	4	7	3.64 (0.51)
I liked that information about **body weight** was included	11	0	0	0	11	4.00 (0.00)

*Calculated based on the following scheme: disagree=1; somewhat disagree=2; somewhat agree=3; agree=4

Participants were asked to indicate the extent to which they agree with various statements about the **amount of information** provided in each topic. Participants' answers are presented in Table 6.9. Overall students agreed with the statements about the adequacy of information provided for each topic (range of means scores: 3.36-3.64). The lowest rating mean scores were found for Fruit & Vegetables (mean score=3.36), Salt (mean score=3.40) as well as Meals & Snacks (mean score=3.40), indicating that students might have wanted more information about these topics.

Table 6. 9. Perceptions of students regarding the amount of information provided in each topic of the e- programme

	n	Disagree	Somewhat disagree	Somewhat agree	Agree	Means (SD)*
The amount of information provided about **activity and exercise** was adequate	11	0	0	6	5	3.45 (0.52)
The amount of information provided about **alcohol** was adequate	11	0	0	5	6	3.55 (0.52)
The amount of information provided about **fast-food** was adequate.	11	0	0	5	6	3.55 (0.52)
The amount of information provided about **fats** was adequate.	11	0	0	5	6	3.55 (0.52)
The amount of information provided about **food-labels** was adequate.	11	0	0	4	7	3.64 (0.51)
The amount of information provided about **fruit and vegetables** was adequate	11	0	1	5	5	3.36 (0.67)
The amount of information provided about **meals and snacks** was adequate	10	0	0	6	4	3.40 (0.52)
The amount of information provided about **meat** was adequate	11	0	0	5	6	3.55 (0.52)
The amount of information provided about **salt** was adequate	10	0	0	6	4	3.40 (0.52)
The amount of information provided about **sugars and sugary drinks** was adequate	11	0	0	6	4	3.45 (0.52)
The amount of information provided about how to **eat on a budget** was adequate	11	0	0	5	6	3.55 (0.52)
The amount of information provided about **body weight** was adequate	11	0	0	6	5	3.45 (0.52)
Additional information could be reached through external links	11	0	0	5	6	3.55 (0.52)

*Calculated based on the following scheme: disagree=1; somewhat disagree=2; somewhat agree=3; agree=4

For each topic on the website information regarding the impact of the eating or activity behaviour on health, the recommended food/drink servings as well as tips and advice to improve dietary and activity behaviour were provided. Participants were asked to indicate to what extent they regarded the various statements about the **type of information** provided for each topic **valuable**. Participants' answers are presented in Table 6.10. Nine out of 11 students rated as valuable or very valuable the information provided about the impact of dietary or activity behaviour on health, 8 out of 11 the information about recommended intakes and 9 out of 11 the tips and advice provided to improve dietary and activity behaviour.

Table 6. 10. Perceptions of students regarding the value of information provided for each topic on the website

	n	Not valuable	Somehow valuable	Valuable	Very Valuable	Means (SD)*
Information on how food/drinks intake or exercise could impact health	11	0	2	6	3	3.09 (0.70)
Information about portion sizes and recommended servings (foods, alcohol, etc.)	11	0	3	5	3	3.00 (0.78)
Tips and advice to improve eating and physical activity habits	11	0	2	6	3	3.09 (0.70)

*Calculated based on the following scheme: not valuable=1; somehow valuable=2; valuable=3; very valuable=4

6.5.6.3 Perceptions regarding the impact of the e-programme on understanding the health topics

Students were asked to indicate the extent to which they perceive the e-programme impact their understanding of the various topics. Participants' answers are presented in Table 6.11. The majority of students reported that the e-programme had a minor or moderate impact toward a better comprehension of the included topics (range of mean scores: 2.09-2.55). Only 1 out of the 11 students reported a major impact towards a better understanding of some of the topics. The lowest rating mean score was found for Sugars and Sugary drinks (mean score= 2.09).

Table 6. 11. Perceptions of students about the impact of the e-programme on their better understanding of each topic

	n	No impact	Minor impact	Moderate impact	Major impact	Means (SD)*
Activity and exercise	11	1	6	4	0	2.27 (0.65)
Alcohol	11	1	7	2	1	2.27 (0.79)
Fast-food	10	0	7	2	1	2.40 (0.70)
Fats	11	2	3	5	1	2.45 (0.93)
Food labels	11	1	4	5	1	2.55 (0.82)
Fruit and vegetables	11	1	5	4	1	2.45 (0.82)
Meals and snacks	11	1	6	4	0	2.27 (0.65)
Meat	11	2	3	5	1	2.45 (0.93)
Salt	11	0	6	5	0	2.45 (0.52)
Sugars and sugary drinks	11	4	3	3	1	2.09 (1.04)
Eating on a budget	11	1	5	5	0	2.36 (0.67)
Body weight	11	1	6	3	1	2.36 (0.81)

*Calculated based on the following scheme: no impact=1; minor impact=2; moderate impact=3; major impact=4.

6.5.6.4 Perceptions about the delivery, feasibility and sustainability of the programme

Participants were asked to indicate the extent to which they agree with various statements about the **delivery**, **feasibility** and **sustainability** of the online programme. Their responses are presented in Table 6.12. All (11/11) participants agreed that in the beginning they received clear information and guidance about the study and were able to contact the PI of the study any time. In addition, 10 out of 11 students agreed that the programme was easily accessible and 8 out of 11 students agreed that delivering the programme online was an appropriate approach. Nine out of 11 students agreed that the programme had a good duration and it did not bear much on their leisure time. All except three students agreed that the programme was flexible and it could be easily implemented within university settings (both mean scores = 3.64). Although not all students would recommend the programme to their friends, all agreed that it was informative, and a good use of their time, and they would participate in similar programmes in the future (range of mean scores: 3.73-3.82).

Table 6. 12. Perceptions of students regarding the delivery, feasibility and sustainability of the online programme

	n	Disagree	Somewhat disagree	Somewhat agree	Agree	Means (SD)*
The information provided prior to the start of the programme was useful and clear	11	0	0	1	10	3.91 (0.30)
I was aware of what I was expected to do as a participant in the programme	11	0	0	0	11	4.00 (0.00)
I could contact the lead investigator of the programme at any time for clarifications or other reason	11	0	0	0	11	4.00 (0.00)
The programme was easily accessed	11	0	1	5	5	3.36 (0.67)
The delivery of programme online was an appropriate approach	11	0	0	3	8	3.73 (0.47)
The programme had a good duration	11	0	0	2	9	3.82 (0.41)
The time needed for the programme was bearable	11	0	0	2	9	3.82 (0.41)
The programme provided flexibility	11	0	2	0	9	3.64 (0.81)
The programme could be easily implemented within university	11	0	1	2	8	3.64 (0.67)
Overall the programme was informative and useful	11	0	0	3	8	3.73 (0.47)
I would recommend my friends to engage in this programme	11	0	1	4	6	3.45 (0.69)
I would participate in similar programmes in the future	11	0	0	3	8	3.73 (0.47)
Participating in this programme was a good use of my time	11	0	0	2	9	3.82 (0.41)

*Calculated based on the following scheme: disagree=1; somewhat disagree=2; somewhat agree=3; agree=4

6.5.6.5 Additional comments by students

Only one student responded to the question about what other features they would prefer for this online programme, suggesting the use of a diet and exercise diary. Five students responded to the question asking about what other online or technology tools they would recommend for similar programmes and eight students replied to the question related to what other approaches (besides using the world wide web or technology) they would suggest for similar health promoting programmes. Their responses are presented in Table 6.13. Students suggest the use of gadgets for tracking exercise (n=1), mobile applications (n=1), recipes (n=1) and knowledge competitions with healthy food-prizes (n=1). Regarding non-web means, students suggest the use of sign-posting within universities to promote health behaviour (n=2), interventions within cafeterias and shops such as reduced prices for healthier foods, increased availability of healthy options and POP information (n=3) as well as social events or workshops for promoting healthy eating (cooking classes, fairs, etc.) (n=3). Finally, students were asked to share any additional thoughts regarding the programme. Only three provided answers; one responded that the programme was very interesting and well-delivered; one provided a similar answer but also suggested having involved participants more and one mentioned that the quizzes were not helpful for memorising information.

Table 6. 13. Students' thoughts about additional features they would have liked in health-promoting programmes

Question	Responses
What other online tools or technology-based methods would you like the university to implement to increase awareness about healthy eating and physical activity among students?	"Competitions among students (maybe anonymously rated) based on knowledge and prizes in the form of healthy snacks"
	"Perhaps a simple recipe book could be provided in each kitchen".
	"Perhaps an app would be good rather than an online desktop version…"
	"If the website and quiz was accessible to all university students it may be useful"
	"fitness trackers"
Besides online or technology-based methods, what other programmes or actions would you like the university to accommodate to increase awareness about healthy eating and physical activity among students?	"More healthy food options (both at the cafeteria and shops)"
	"Cooking lessons!!! Also a great way to socialise"
	"I think sign-posting is important e.g. having signs outside lifts and by stairs that can act as prompts for individuals which make them think about which option they are going to take rather than just automatically going for the lift"
	"Fairs, booths at the school foyers, special menus from the canteen, competitions".
	"Posters around the campuses, health talks that are free to attend, more awareness of all the sports clubs available".
	"Create workshops to show students free apps they can use to track their health"
	"Information provided in canteen on sugary drinks, processed food available in canteen, their impact etc. Similar to how you find information on pack of cigarettes about their health impact."
	"Definitely integrating better prices for healthier options!"

6.6 Discussion

6.6.1 The impact of the e-programme on the outcomes of the study

The aim of the study was to investigate whether an online educational programme using quiz-games would improve nutrition knowledge, diet quality and level of physical activity in a sample of university students in the UK. The study found no significant impact of the e-programme on any of the outcomes of interest between the two groups of the study over time (Tables 6.4-6.5). Direct comparisons with other studies cannot be made as this was the first study to have used quiz-games as the main component of the intervention to improve nutrition knowledge and diet quality in university students. Among studies that used quizzes as part of their online interventions, only Greene et al. (2012) targeted diet, with the intervention group consuming 0.5 cups more fruit and vegetables per day compared to the intakes of the control group at follow-up. Among studies that targeted physical activity behaviour, Okazaki et al. (2014) and Greene et al. (2012) were ineffective. In terms of using online gaming for learning, two studies were found targeting physical activity outcomes (Huang et al., 2009; Johnston et al., 2012). Both studies were ineffective in changing physical activity behaviour in the long-term, although the study by Huang et al. (2009) improved self-efficacy towards physical activity and the study by Johnston et al. (2012) increased walking activity. Therefore, the results of this study agree with the findings of these studies, suggesting that online approaches including quizzes or gaming are not effective in improving physical activity behaviour while no similar studies exist targeting diet quality to draw comparisons.

Many reasons might explain why the e-programme was not effective in this study. Firstly, although students were randomly assigned to two groups, significant differences were found at baseline with more students from a non-healthcare field of study and an unhealthy BMI/Body Fat index resulting in the intervention group (Table 6.3). Although the intervention might benefit these students more, evidence shows that students from a non-healthcare field have lower levels of nutrition knowledge (Sajwani et al., 2009), therefore, more effort might be needed to achieve a significant gain in knowledge. A larger sample size would have allowed to explore further the impact of the intervention over time within the various subgroups of students (healthcare versus non-healthcare and those with healthy versus unhealthy BMI/BF indexes). In addition, during the baseline anthropometric and clinical assessments, students could see their values on the monitors of instruments, which might have had an impact on their initial motivation to improve their lifestyle habits, especially if measures were within normal ranges. The baseline characteristics also indicated that both groups did not have very low scores of nutrition knowledge and diet quality while about 50% of students in both groups were engaged in high levels of exercise (Table 6.3). As a result, there might not be enough room for improvement for these students and having recruited students with very poor knowledge or lifestyle habits might have resulted in significant improvements. For example, Fischer & Bryant (2008) found that students who were not doing but thinking of starting to exercise in the next months at baseline increased significantly their activity behaviour at post-intervention compared to students who were already exercising before the intervention. In this study, an ITT analysis was used, considering the data of non-completers remained unchanged at post-intervention. This approach tends to de-emphasise the magnitude of the intervention on outcomes, considering also that a significant higher number of students in the intervention group did not complete the study compared to the control group (Table 6.3.). The short duration (10 weeks) of the intervention might also explain the no impact found as participants might needed more time to engage with the e-programme and process the given information.

6.6.2 Adherence to the e-programme

Adherence to the e-programme is another reason that might explain the findings of this study. The systematic review by Donkin et al. (2011), which investigated the impact of adherence to e-interventions on health outcomes, found a positive correlation between adherence to e-programmes and dietary and weight-related outcomes, although less than half of the identified studies had assessed adherence. The most frequent methods used for measuring adherence to these programmes included tracking logins and completed activities (e.g. engage in online tests) (Donkin et al., 2011). In this study, adherence levels to the e-programme did not impact nutrition knowledge (Table 6.6). This might be explained by the fact that students who did not play any game still received the financial compensation at the end of the study, resulting in 15 out of 50 students (30%) from the intervention group nearly playing any game. Additionally, adherence was only estimated by measuring the number of times games were played without considering exposure to the website. As a result, adherence might have been underestimated as students could not play any game but still increase their knowledge via the website. The findings of this study are consistent with those of Epton et al. (2014), which found that adherence to the intervention had no impact on dietary intake and physical activity.

6.6.3 Quiz-games

In general, engagement with the quizzes was low. Very few students played all games, with students playing on average 6 out of 10 games. Activity was the most popular game followed by Fast-food and Alcohol (Figure 6.3). Although students were aware that one of the main objectives of the e-programme was to increase their knowledge, it is unknown whether they played quiz-games related to topics they were most interested in or more knowledgeable about. When comparing the frequency of playing a game (Figure 6.3) with the performance on the same game (Figure 6.5), one can assume that learning was not the main motive of students as the most frequent played games had the highest performance and vice versa. In particular, the Activity game, which was played by almost all students engaged with the intervention, had the highest mean number of correct answers while the game of Salt, which was the least played game, had the lowest mean number of correct answers, meaning that students seemed to avoid playing the games of which covered topics they felt least knowledgeable. This was enhanced by the fact that each correct answer increased their score, thus students might consider it more important to increase their game score and be competitive rather than take the risk of playing games in which they might score lower. As a result, quiz-games seemed to have promoted surface learning rather than deep learning in this study. Surface learning is characterised by accepting new information passively without processing them while deep learning involves critical thinking of the acquired knowledge, connection to previous knowledge and integrate of knowledge into real life (Entwistle, 1988; Ramsden, 1992; Biggs, 1999). A further analysis among students who played some games twice showed that the quizzes were only effective in improving knowledge in the short-term (Figure 6.6). When repeating a game within eight days, the performance (score) of the game improved, but after that time-point the score remained the same or decreased. This confirms again the theory of surface learning and the speculation that students memorised the information for a short period of time without processing deeply the learning material.

The use of Behaviourism theory to develop the quiz-games to enhance learning and behaviour, might also explain the null outcomes found in this research. This is because the theory is based on the stimulus-response principle without considering other factors that affect individuals' behaviour such as mood, cognition and social interaction (Moore, 2013). Particularly with food, it is well established that dietary behaviour is highly affected by external and internal stimuli, as the consumption of specific foods could be driven by individuals' positive or negative feelings, company, visual cues and food availability (Schüz et al., 2015). As a result, it cannot be excluded that students' past experiences in relation to the nutrition topics or their feelings and mood the time they were playing the quiz-games might have had an impact on their learning and behaviour. In addition, although Behaviourism is frequently used in technology-based learning through repetition, direct instruction and feedback, it has been criticised for considering behaviour as 'mechanistic' and not taking into account the complex human nature and critical thinking, which are used in the Constructivist principles of learning (Gökmenoğlu et al., 2010). Constructivism could have been applied in this research by allowing students to create their own quiz-games or reflect and critically discuss their responses to the quiz-games; however, such activities were not feasible, enhancing the limitations of using Behaviourism on learning and changing behaviour.

6.6.4 Evaluation study

The findings of the evaluation study confirm some of the above speculations. Firstly, improving lifestyle habits was not the main motive for some students to take part in the study, with other motives included curiosity or helping other students with their PhD research projects (Table 6.7). Overall, students enjoyed knowing facts about their body composition and health status with some students suggesting including more similar measurements (e.g. blood cholesterol or fitness tests) in such programmes. The health topics of the e-programme were well received by students (Table 6.8) with some participants recommending adding topics related to vitamins and minerals, processed foods and food intolerances. Students were also asked about the amount of information available for each topic, with the majority agreeing that information was adequate (mean scores $\geq$ 3.36) (Table 6.9). The lowest scores of agreements were found for the games of Salt, Fruit & Vegetables as well as Meals & Snacks, indicating that students might have wanted more information on these topics. This might also explain the low performance found for the Salt quiz-game (Figure 6.5). Students regarded as more useful giving tips and advice to improve habits as well as information on how eating and exercise behaviour affects health rather than providing information on portion sizes (Table 6.10). Evidence suggests that many individuals regard counting food portions restrictive, while consuming foods low in energy and/or fat without considering portions might be more beneficial for weight management compared to restricting food intake (Ello-Martin et al., 2005).

Students reported that the e-programme had a minor or moderate positive impact on their understanding of the health topics (Table 6.11). This aligns with the quantitative findings of the study where no effect of the e-programme was found on students' nutrition knowledge, diet quality and physical activity behaviour. Despite the perceived low impact, most students agreed that participating in the e-programme was useful and informative and were satisfied with its overall delivery, including its duration, online approach and information provided at induction (Table 6.12). Students reported that they would participate in similar programmes in the future, however, they suggested including more social or group activities such as recipe books, cooking classes, workshops, competitions, talks and fairs (Table 6.13). Although students recommended social and group activities, none suggested using a one-to-one approach. This is consistent with the findings presented in the **Overview** (Chapter 4), showing a very low effect of tailored or peer interventions on weight-related health behaviours in university students (Table 4.6). This is contradicting the concept presented by Cousineau et al. (2006), which suggest that the 'one fits all approach' is less favourable than a personalised approach. Students also suggested adding sign-posters and POP information with healthy messages in canteens as well as increasing the availability of more healthy options at better prices at university cafeterias and shops. These results are in line with the findings of the **Overview** (Chapter 4) which demonstrated that environmental interventions, including POP information and price incentives, were very effective in increasing sales of healthy food items and were well-accepted by students.

6.6.5 Strengths and limitations of the study

Compared to a quasi-experimental design, random allocation reduced the possibility of confounding factors that might affect differences found between the two groups. Due to ethical concerns, participants were aware of the existence of both groups. Intention to treat analysis maintained the advantages of random allocation, as participants that dropped out were included in the analysis. The sample size of the study had sufficient power to detect significant differences between the two groups as discussed in the **Research Methods and Procedures** (Chapter 3, section 3.5.3.2). However, a larger sample size was needed to explore the impact of the intervention according to the level of adherence to the intervention. Recruitment occurred throughout one academic year to consider seasonal factors as specific periods during the academic year (first year, exam periods) found to affect weight-related behaviours of students (Deliens et al., 2014; Deliens et al., 2015a; Vadeboncoeur et al., 2015). Although a great effort was put to equally recruit participants from all scientific disciplines, and no further selection biases were applied, more students from a non-healthcare course were assigned to the intervention group. This might have affected the impact of the intervention on outcomes, as evidence suggests that students from healthcare courses, such as nurses and midwives, have a high prevalence of being overweight (~50%) and despite their role to promote health, they find it difficult to follow a healthy lifestyle (Luszczynska and Haynes, 2009).

Nutrition knowledge, diet quality and physical activity were assessed using reliable and widely used tools and self-reported anthropometric measures were avoided to increase accuracy of data. The PI was present to provide assistance in calculating food portions and amount of time spent on physical activity and ensure that students would not search online for the correct answers when completing the questionnaires. Duration of the intervention was 10 weeks, which provides sufficient time to engage with the programme without it becoming a burden such as taking much away from their leisure time, but a follow-up assessment to estimate the long-term impact of the intervention on outcomes did not take place. However, limitations regarding the usability of the quiz-games that were not tested during the pilot phase, such as playing most frequently the quiz-game that appeared first on the website, launching all quiz-games simultaneously instead of gradually (e.g. one quiz-game per week) to ensure that participants engaged in all quiz-games, the time of assessment (students' overall nutrition knowledge was not assessed straight after playing the quiz-games) as well as potential issues with internet availability and accessibility, should be considered. Finally, the evaluation study that followed-up the RCT allowed to get a deeper understanding of participants' perceptions with regards to the feasibility and sustainability of the programme, although qualitative research (e.g. focus groups) would have provided a more in-depth analysis of students' perceptions and experiences.

6.6.6 Conclusion and future implications

Online quiz-games were not effective in improving nutrition knowledge, diet quality and level of physical activity in the current study. Online gaming, although it is attractive and fun to young people, seems to promote surface rather than deep learning, with students being more motivated to increase their scores or get the game-awards rather than to increase their knowledge. Therefore, future research should consider adding components in game-learning which can promote critical thinking and practical skills in relation to diet and physical activity behaviour. Researchers should also consider evaluating the initial level of nutrition knowledge and motivation to change eating and exercise behaviour of students before implementing similar interventions. It is also highly recommended to get students' opinion and attitudes with regards to their preferred health topics before designing similar interventions by conducting focus groups. Web-based programmes seem to be well-accepted and easy to implement in student populations, however, they might not be sufficient to provide robust changes in health outcomes. Adding social activities (e.g. cooking classes, workshops) and intervene with the university environment (cafeterias, gyms) as well as providing online educational resources might be the key elements of successful interventions in the future to improve dietary and physical activity behaviour in university students.

Chapter 7. Concluding Discussion

7.1 Overview of the chapter

Chapter 7 outlines the key findings of the studies undertaken as part of this research project and provides an overall summary and interpretation of the results, in line with the objectives of the thesis. Based on the key findings, recommendations and implications are presented for future research but also actions and practices that universities could implement and accommodate to increase physical activity and improve the level of nutrition knowledge and diet quality of their students. The chapter summarises the strengths and limitations of the overall research and concludes the contribution of this work into research and the next steps of the PI in the field.

7.2 Summary of findings and discussion

The current research was driven by the Health Promoting University initiative and the existing evidence demonstrating the unfavourable changes in dietary and physical activity behaviour in students while studying at university. Adopting and maintaining healthy lifestyle habits while at university can positively impact students' health and reduce the risk of chronic diseases in their later life. Based on this context, the objectives of the current research project were to identify and estimate the effectiveness of interventions aiming to improve weight-related behaviours in university students, explore gaps and predictors of nutrition knowledge in students and measure the impact of an online game-based intervention on students' nutrition knowledge, diet quality and physical activity. To address these objectives, an overview (systematic review of systematic reviews), a cross-sectional study and a randomised controlled trial followed by an evaluation study were undertaken as part of this research project.

The baseline findings of the RCT demonstrated that most participants had a healthy BMI and body fat content and a low metabolic risk, probably due to the high amounts of exercise reported. However, the diet quality was found low in the same population (baseline scores less than 10) (Table 6.3). These findings are consistent with those of large epidemiological studies in the UK demonstrating that 20% of students had an increased BMI (Nikolaou et al., 2015) and 35% participated in vigorous physical activity but only 15% consumed the recommended daily portions of fruit and vegetables (El Ansari et al., 2011). These trends suggest that more emphasis should be placed in improving diet rather than physical activity of students in the UK.

With respect to the settings where the current research was undertaken, the two universities seem to support exercise at a greater extent than healthy eating. It was noticed that during the research period, students had the opportunity to easily access the sports' centres located on the campuses and register at a low price. There were also designated parking spaces for bicycles in both settings with KU further supporting a bicycle scheme. Universities offered additional extra-curriculum activities (yoga classes, meditation, sign-posting to use the stairs) during the years of the research. On the other hand, no similar activities were noticed that promoted healthy eating. Confectionary foods, sweets and other fast-foods (pizzas) were sold in fairs and promotional campaigns at low prices to collect money for the charity purposes. Workshops or seminars organised by the universities' staff often offered beverages (coffee, tea, juices), snacks (biscuits, muffins) and, in big events even food (pizzas, finger food) to attendees. Furthermore, the menu of the universities' cafeterias included mainly fried and high fat foods and very few healthy options (salad bars, soups). These actions, or lack of actions, could partially explain the high levels of physical activity but low diet quality found at baseline in the sample population of the study (Table 6.3).

Kingston University is a member of the Healthy Universities network in the UK but without executive commitment, while St George's, University of London is not listed as a current member (www.healthyuniversities.ac.uk). It is unknown to what extent KU promotes healthy eating as part of this initiative. The **Overview** (Chapter 4) undertaken as part of this research project found that interventions implemented at universities were mostly face-to-face (51 identified) followed by environmental (36 identified) and e-interventions (30 identified). The overview demonstrated that none the interventions managed to provide robust favourable changes in dietary intake and physical activity behaviour in students (overall effect less than 47% for these outcomes) (Table 4.6). Also, no studies with environmental changes aiming to improve physical activity were identified (Table 4.5), implying that researchers might consider that universities are already 'exercise-friendly' settings and no further environmental changes are needed.

Of the 122 identified studies in the overview, the majority took place in the US and only 7 were implemented in the UK, highlighting the paucity of evidence in the country. Of these, two followed an environmental approach (Aaron et al., 1995; Nikolaou et al., 2014), two followed a face-to-face approach (Chapman, 2009; Zhang & Cooke, 2011), two applied a web-based programme (Skår et al., 2011; Epton et al., 2014) and one used technology (Tully & Cupples, 2011). Both web-based approaches used questionnaires to assess physical activity and were ineffective, which are in line with the results of the current RCT (Table 6.5). Among studies that targeted diet, only face-to-face approaches demonstrated positive changes, focusing on increasing FV intake (Chapman, 2009; Zhang & Cooke, 2011) and decreasing fat (Zhang & Cooke, 2011). Indeed, these are frequently targeted outcomes also found in the overview (Appendix II.C, Supplemental Table 2). However, consuming the recommended FV intake or reducing fat does not suggest that students follow an overall prudent diet. No web-based approaches targeting dietary outcomes were identified in the UK to draw direct comparisons with the findings of the RCT of this research.

Studies in the UK that used similar (web-based) approaches suggested that non-adherence, unclear wording and guidance (Skår et al., 2011) as well as targeting more than one health behaviour (Epton et al., 2014) might be potential reasons explaining the lack of impact of the e-programmes on health outcomes in students. In the current RCT, the impact of the level of adherence on outcomes was explored and found non-significant (Table 6.6), although the results should be interpreted with caution as many students dropped out of the study (23 out of 88) or did not engage with the intervention (12 out of 50 had low adherence). With respect to multiple behaviours, the e-programme focused on diet rather than physical activity, with 9 out of 12 health topics on the website and 9 out of 10 quiz-games addressing diet and eating behaviour, and only one (topic and game) addressing physical activity and exercise (Table 6.1). The evaluation study that followed-up the RCT demonstrated that students did not report difficulties regarding the clarity of the information provided and responded positively to the statements inquiring about the overall delivery and feasibility of the intervention (Table 6.12).

Consequently, potential reasons for the non-significant changes observed in the RCT of this research included the initial motivation and health expectations of students and the lack of engagement with gaming to promote deep learning. Improving health was not the dominant motive of students who took part in the trial, as reported in the evaluation questionnaire (Table 6.7) despite students' keenness to undertake the anthropometric measures and learn about their health status at the beginning of the study (Table 6.8). Moreover, the cross-sectional study undertaken as part of this research project (Chapter 5) found that students who perceived their health as very good or excellent demonstrated high levels of nutrition knowledge (Table 5.5), suggesting that participants with perceived healthy profiles at the beginning of the trial might have felt less motivated to increase their knowledge or change their lifestyle habits.

The use of quiz-games as a learning approach could also explain the lack of effect of the e-programme. Analyses of the data of the games revealed that participants chose to play their 'favourite' and most familiar quizzes rather than the ones they may have found challenging (Figures 6.3-6.5). This was potentially driven by their endeavour to collect points and reach the maximum score rather than aim to absorb and process the new information. This was further confirmed by the short-term effect the quizzes had on students' ability to memorise the learnt material, as students would start to forget the correct answers to the game-questions if repeated the game after eight days (Figure 6.6). These findings were cross-validated by students, who rated that quiz-games had a minor impact on their knowledge of the health topics (Table 6.11). Based on this evidence, one can speculate that gaming is fun and engaging but seems to promote surface learning. In surface learning, students try to learn and memorise information to achieve a short-term goal such as pass an exam or achieve high grades without absorbing and critically processing the information or trying to relate the information to every day experiences (Lindblom-Ylänne et al., 2018). As a result, surface learning has weak potential to achieve long-term behavioural changes.

In general, increasing knowledge is an acceptable approach to promote healthy eating, as the cross-sectional study of this research (Chapter 5) demonstrated that an increase in knowledge was positively associated with better diet quality in students. It is important though to provide targeted information, as not all information was positively related with diet quality. In this research study, knowledge on healthy food choices and diet-disease relationships were positively associated with diet quality in students (Table 5.7). It should be noted that students also favoured information regarding the impact of diet on health and practical advice to improve their daily habits as shown in the evaluation study (Table 6.10). There are no established thresholds to indicate a good level of knowledge, and more research is needed to find the cut-off point above which a good knowledge has significant benefits in dietary behaviour or diet quality. As a result, the level of knowledge is presented by measuring the sum of correct answers out of the total questions.

The findings of the cross-sectional study undertaken as part of this research project (Chapter 5) demonstrated that students were least knowledgeable about nutrients contained in foods (Table 5.3), particularly related to fats, salt and practices to prevent weight gain or maintain a healthy body weight (Figure 5.1). The fact that participants were unable to recognise optimal weight management practices questions the validity of the sources students use to search for such information on the internet and the potential risk they would follow unhealthy weigh loss methods. Information about fat and salt also appears on food labels and, considering the low knowledge found on food labelling (Figure 5.1), one can assume that students either do not understand or do not use food labels when shopping. Fat is a complicated nutrition concept, due to the different types of fat in diet, namely monounsaturated, polyunsaturated, saturated and trans-fat, and their different impact on health. For example, food sources of saturated and trans-fat are harmful for health, while replacing foods containing saturated fat with foods rich in mono- and poly-unsaturated fat, is very beneficial for health. Such terminology is difficult to comprehend and memorise, especially for students who are not studying a health-related course or may not feel the need to know given their relatively healthy status.

Indeed, students from health scientific disciplines had significantly greater knowledge compared to their counterparts from other scientific disciplines (Table 5.5). However, it is not clear whether these students 'take advantage' of this greater knowledge and use it in their daily life to improve their diet. Ethnic origin was another factor affecting nutrition knowledge, with students of White ethnic origin demonstrating significantly greater levels of knowledge compared to students from other ethnic backgrounds (Table 5.5). As food is part of the culinary tradition, it is somehow expected that people from different cultural and ethnic backgrounds will not fully assimilate the UK dietary recommendations, particularly those who just arrived in the UK to study or are only here temporarily until they graduate. Nevertheless, these findings suggest that UK universities should make a greater effort to address and incorporate the food habits and culinary traditions of students from other countries when designing health-promoting interventions.

7.3 Implications of the body of research

7.3.1 For research

The current research project suggests that a greater effort should be placed on improving diet rather than physical activity in the university students in the UK. There is a lack of evidence in the country regarding the level of nutrition knowledge and its relation to dietary intake and more research is needed to explore the academic and other factors that hinder good dietary practices in students. Undertaking epidemiological studies, but also collecting data through interviews or focus groups to explore students' perceptions and attitudes on food, as well as their motive to change behaviour, is highly recommended before designing interventions. Additionally, the sources that students use to search for nutrition information are important to be explored in order to design successful interventions. A higher number of long-term RCTs are needed in the UK to estimate the efficacy of interventions on health outcomes which, if synthesised in a meta-analysis, would provide robust evidence on the effect sizes of the changed outcomes. Researchers should focus on improving dietary habits as a whole (diet quality, dietary patterns) and not only on specific groups of foods, particularly when participants are healthy students. Furthermore, a greater consistency is needed in the assessment methods and reporting of dietary outcomes to allow synthesis of data. In general, there was paucity of studies using combined modes interventions (face-to-face, environmental and e-interventions) and more research is needed in the field to estimate their effectiveness. Finally, environmental approaches seem promising for increasing awareness on healthy eating by affecting food choices. However, the majority of the identified interventions followed an interrupted time-series design, lacking in many studies randomisation and control of sample size. As a result, there is need for more randomised controlled trials to estimate the effectiveness of environmental interventions on food sales but also on dietary intake, as purchasing a food does not guarantee its consumption by the purchaser.

Factors that affect nutrition knowledge and diet quality, in particular the field of study and ethnic background of students, should be considered when undertaking similar interventions in the future. Students enrolled on health courses seem to have higher levels of knowledge, however, additional research is needed to verify whether these students also follow better dietary habits compared to students from non-health courses. It is highly recommended for future interventions to focus on students from practical sciences and those from ethnic minorities, including those who just moved to the UK to study. It will also be interested to compare the findings of studies implemented between universities based in- and outside of the London area to explore the impact of ‘city-life’ on the dietary and physical activity behaviour of students.

7.3.2 For education

Using the world wide web was efficient to deliver the educational intervention while students reported that they did not face difficulties in accessing and using the e-programme. It is suggested that the world wide web could be used for educational purposes as a low-cost and easily-accessible source of information. However, it is important for websites to include valid and clear information which is easy to navigate. The use of constructivist components in technology-based education to improve nutrition knowledge and dietary behaviour should be further explored. In particular, researchers should aim to design games which will be more interactive and increase students’ critical skills. For example, asking students to build virtual healthy meals from different foods with instant feedback on their energy and nutrient content in order to collect 'nutrient-points', might be an example of an interactive game-learning approach. In the current research the motive to collect points exceeded the motive to learn in students. Smartwatches are a good example of how technology has been used to increase physical activity. People wearing a smartwatch are driven by the motive to reach the goal of 10,000 steps per day. Game-learning could be used in a similar way to motivate people to compete 'themselves' and improve their own dietary behaviour. In addition, the platform used (Kahoot!) to create the quizzes allows students to create their own quizzes, a feature not used in this research. Therefore, it is worth investigating whether asking students to create their own quizzes to compete with their classmates would be more effective, as critical thinking skills would be required. As a result, the current research does not discourage the use of gamification or quizzes to increase nutrition knowledge and improve diet but emphasises the need of incorporating engaging elements and practical skills which will impact on students' dietary behaviour. Furthermore, it is recommended that web-based approaches be applied in parallel with hands-on activities such as workshops, seminars and social events (i.e. combined modes of interventions).

7.3.3 For practice

Universities could undertake a series of actions to increase the diet quality and physical activity of students. With regards to physical activity, building sports centres nearby the campuses, offering bicycles for rent and parking spaces for bicycles, creating universities' sports teams, sign-posting the use of stairs instead of lifts and organising other extra curriculum activities are examples of good practices which may increase physical activity of students. Since many universities already accommodate for some of these practices, more emphasis should be placed during the exam periods where students tend to decrease their exercise, by offering more spiritual and relaxing activities (stretching, yoga classes, etc.).

Universities could also apply a series of actions to improve diet quality of students. Firstly, during the student induction period, it is recommended to distribute booklets with information about nearby grocery shops, restaurants and markets, with a brief description of their products. Also, a cookbook with easy-to-make recipes and suggestions for healthy meals and tips on how to buy healthy foods on a budget could be given to all students. The university could organise frequent workshops to demonstrate students how to cook and handle food safely while preparing and storing meals (e.g. using different cutting boards for raw and cooked foods) as well as how to read and interpret food labels. In addition, staff (dietitians/nutritionists) of the universities could develop a website where students would find information about diet and health or guide students to valid online resources. Additionally, universities could offer one-to-one nutritional counselling to students who wish to seek further advice to improve their diet and decrease their body weight. Sign-posts with healthy eating messages are recommended to be posted on university premises, particularly during exam periods, to remind students to take care of themselves and provide their body with the necessary nutrients. Finally, both the university and the Government should encourage university catering services and cafeterias to change their policy and include healthier food and drink options for better prices. In particular, the university should collaborate with the cafeterias and provide students with a detailed description of the energy and nutrient content of the offered meals, including information on allergens. Students' voice regarding the cafeteria food should be heard by conducting surveys where students can vote about the quality and availability of the served food. Placing food labels at cafeterias' POP points might also be helpful for students to make the right choices. It is good practice to place vending machines with sign-posts and healthy options as well as water fountains at the university areas. Finally, universities should ensure the availability of comfortable sitting areas where students can eat home-packed meals where equipment (cutlery, microwaves) to facilitate the eating experience of students is also provided.

7.4 Strengths and limitations of the research project

The current research used quantitative research and an overview of the literature to address the objectives of the thesis. The overview followed specific guidelines (PRISMA) and provided great insights with regards to the different types of interventions and outcomes reported in studies. In addition, the overview estimated the overall effect of each type of intervention on the outcomes of interest by using the method of vote counting. One could argue that a meta-analysis would have provided a more accurate estimate of the effect size of changes, however, due to the heterogeneity of the findings, a pooled analysis was not feasible. The current project aimed to provide new evidence with regards to the knowledge of students on various nutrition topics through a cross-sectional study. Additionally, it explored the impact of an e-programme on nutrition knowledge, diet quality and physical activity in students by implementing a randomised controlled trial and followed by an evaluation study. Two London-based universities were used for the purposes of these studies. One of the two universities offered only health-related courses, which reduces the generalizability of the results, however, it also provided the opportunity to explore the impact of the field of study on outcomes.

In both studies, the validated and revised General Nutrition Knowledge Questionnaire was used to explore the knowledge on recently updated nutrition data. To the best of our knowledge, this is the first research project using the updated version of the questionnaire. A valid semi-quantitative FFQ questionnaire, including questions which reflect the dietary practices of students, was used to assess diet quality in both studies and explore the potential relationship of nutrition knowledge with diet. Physical activity was assessed using the widely used and validated IPAQ-SF questionnaire while pedometers were given to students to assess their walking activity. Unfortunately, most students did not use the pedometers properly in order to provide accurate data, thus these data were not used in the data analysis. The use of accelerometers would have provided more accurate data regarding the level of physical activity of students, but financial limitations restricted their use. The sample size in both studies was calculated in collaboration with the Faculty's statistician to reach a 90% statistical power, based on the available data on nutrition knowledge. However, many students provided incomplete data in the cross-sectional study reducing the statistical power while a larger sample size would have allowed for further between-group comparisons in the RCT (for example, to explore whether the e-programme had a different impact between the intervention and control group, based on the field of study of students). Another limitation was the use of self-reported measures of body weight and height in the cross-sectional study in contrary to the RCT, where all measures were undertaken by the PI using state of the art equipment. Socio-demographic and other factors correlated with the outcomes were collected and used in the analysis to increase the accuracy and validity of inferences. Finally, the evaluation study that followed the RCT aimed to get a better understanding of participants' experiences and perceptions with regards to the feasibility and sustainability of the e-programme by asking open- and closed-ended questions, although the use of qualitative research (e.g., focus groups) would have provided a more in-depth analysis of students' perceptions.

7.5 Concluding remarks and next steps

The current research project has made a unique contribution in providing new evidence in the level of nutrition knowledge of university students in the UK and the impact of an online game-based intervention on nutrition knowledge, diet quality and physical activity of students. It also provided a great insight with regards to the different types of interventions in the field and their overall effect on dietary, physical activity and weight-related outcomes in university students. Based on the key findings, recommendations were made for research and educational purposes as well as actions that universities could undertake to promote physical activity and diet quality of students. The author of this thesis and principal investigator of the research plans to investigate further the topic by conducting qualitative research (focus groups) among university students to explore their attitudes about healthy eating and the sources of nutrition information that students use. She also plans to analyse further the responses of students to the quiz-games to get an in-depth understanding of students' knowledge and misconceptions on each health topic. Finally, the findings of the current research project motivated her to conduct in the future additional research within UK HEIs to explore the nutrition knowledge and dietary behaviour of students from ethnic minorities and those students born or residing outside the UK.

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Appendices

Appendix I. Questionnaires used in the research project

Appendix I.A. Physical Activity Readiness Questionnaire

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	1. **Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2. **Do you feel pain in your chest when you do physical activity?**
☐	☐	3. **In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4. **Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5. **Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6. **Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7. **Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____

SIGNATURE ____ DATE ____________________

SIGNATURE OF PARENT ____ WITNESS ____________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

Appendix I.B. The SCOFF (Sick, Control, One stone, Fat, Food) questionnaire

SCOFF Questionnaire - Test for Detecting Eating Disorders

The **SCOFF Questionnaire**, devised by researchers at St George's Hospital Medical School, is a valid and reliable screening tool for detecting the existence of an eating disorder. The questions focus on some key characteristics of **anorexia** and **bulimia**.

*** SCOFF Questionnaire ***

1. Do you make yourself **S**ick because you feel uncomfortably full?
   - ☐ Yes
   - ☐ No
2. Do you worry you have lost **C**ontrol over how much you eat?
   - ☐ Yes
   - ☐ No
3. Have you recently lost more than **O**ne stone in a 3 month period?
   - ☐ Yes
   - ☐ No
4. Do you believe yourself to be **F**at when others say you are too thin?
   - ☐ Yes
   - ☐ No
5. Would you say that **F**ood dominates your life?
   - ☐ Yes
   - ☐ No

Interpretation of Results

If you answer 'No' to every question, the test indicates you do not have an eating disorder. If you still think you may have an eating disorder, see your doctor.

If you answer 'Yes' to 1 question, with the rest answered as 'No', the test indicates you do not have an eating disorder. However, it does suggest you may have some issues with food or your body image. If you are in any doubt about whether or not you have an eating disorder, see your doctor.

If you answered Yes to at least 2 questions, the test indicates you may have **Anorexia Nervosa** or **Bulimia Nervosa**. This is not a diagnosis, but it is possible you have an eating disorder that needs further investigation by a qualified health professional. Please see your doctor.

Appendix I.C.i General Nutrition Knowledge Questionnaire (adapted from Kliemann et al., 2016)

General Nutrition Knowledge Questionnaire - T1

Section 1: The first few items are about what advice you think experts are giving us.

2. Do health experts recommend that people should be eating more, the same amount, or less of the following foods? Tick one box per food.

	More	Same	Less	Not sure
Fruit	○	○	○	○
Food and drinks with added sugar	○	○	○	○
Vegetables	○	○	○	○
Fatty foods	○	○	○	○
Processed red meat	○	○	○	○
Whole grains	○	○	○	○
Salty foods	○	○	○	○
Water	○	○	○	○

3. How many servings of fruit and vegetables per day do experts advise people to eat as a minimum? (One serving could be, for example, an apple or a handful of chopped carrots). Tick one.

- ○ 2
- ○ 3
- ○ 4
- ○ 5 or more
- ○ Not sure

4. Which of these types of fats do experts recommend that people should eat less of? Tick one box per food.

	Eat less	Not eat less	Not sure
Unsaturated fats	○	○	○
Trans fats	○	○	○
Saturated fats	○	○	○

5. Which type of dairy foods do experts say people should drink? Tick one.

- ○ Full fat (e.g. full fat milk)
- ○ Reduced fat (e.g. skimmed and semi-skimmed milk)
- ○ Mixture of full fat and reduced fat
- ○ Neither, dairy foods should be avoided
- ○ Not sure

6. How many times per week do experts recommend that people eat oily fish (e.g. salmon and mackerel)? Tick one.

- ◯ 1-2 times per week
- ◯ 3-4 times per week
- ◯ Every day
- ◯ Not sure

7. Approximately how many alcoholic drinks is the maximum recommended per day? (The exact number depends on the size and strength of the drink). Tick one.

- ◯ 1 drink each for men and women
- ◯ 2 drinks each for men and women
- ◯ 2 drinks for men and one drink for women
- ◯ 3 drinks for men and two drinks for women
- ◯ Not sure

8. How many times per week do experts recommend that people eat breakfast? Tick one.

- ◯ 3 times per week
- ◯ 4 times per week
- ◯ Every day
- ◯ Not sure

9. If a person has two glasses of fruit juice in a day, how many of their daily fruit and vegetable servings would this count as? Tick one.

- ◯ None
- ◯ 1 serving
- ◯ 2 servings
- ◯ 3 servings
- ◯ Not sure

10. According to the 'eatwell guide' (a guideline showing the proportions of food types people should eat to have a balanced and healthy diet), how much of a person's diet should be made up of starchy foods? Tick one.

- ◯ Quarter
- ◯ Third
- ◯ Half
- ◯ Not sure

Section 2: Experts classify foods into groups.

We are interested to see whether people are aware of food groups and the nutrients they contain.

11. Do you think these foods and drinks are typically high or low in added sugar? Tick one box per food.

	High in added sugar	Low in added sugar	Not sure
Diet cola drinks	○	○	○
Natural yoghurt	○	○	○
Ice cream	○	○	○
Tomato ketchup	○	○	○
Melon	○	○	○

12. Do you think these foods are typically high or low in salt? Tick one box per food.

	High in salt	Low in salt	Not sure
Breakfast cereals	○	○	○
Frozen vegetables	○	○	○
Bread	○	○	○
Baked beans	○	○	○
Red meat	○	○	○
Canned soup	○	○	○

13. Do you think these foods are typically high or low in fibre? Tick one box per food.

	High in fibre	Low in fibre	Not sure
Oats	○	○	○
Bananas	○	○	○
White rice	○	○	○
Eggs	○	○	○
Potatoes with skin	○	○	○
Pasta	○	○	○

14. Do you think these foods are a good source of protein? Tick one box per food.

	Good source of protein	Not a good source of protein	Not sure
Poultry	○	○	○
Cheese	○	○	○
Fruits	○	○	○
Baked beans	○	○	○
Butter	○	○	○
Nuts	○	○	○

15. Which of the following foods do experts count as starchy foods? Tick one box per food.

	Starchy food	Not a starchy food	Not sure
Cheese	◯	◯	◯
Pasta	◯	◯	◯
Potatoes	◯	◯	◯
Nuts	◯	◯	◯
Plantains	◯	◯	◯

16. Which is the main type of fat present in each of these foods? Tick one box per food.

	Polyunsaturated fat	Monounsaturated fat	Saturated fat	Cholesterol	Not sure
Olive oil	◯	◯	◯	◯	◯
Butter	◯	◯	◯	◯	◯
Sunflower oil	◯	◯	◯	◯	◯
Eggs	◯	◯	◯	◯	◯

17. Which of these foods has the most trans-fat? Tick one.

◯ Biscuits, cakes and pastries

◯ Fish

◯ Rapeseed oil

◯ Eggs

◯ Not sure

18. The amount of calcium in a glass of whole milk compared to a glass of skimmed milk is: (tick one)

◯ About the same

◯ Much higher

◯ Much lower

◯ Not sure

19. Which one of the following has the most calories per gram? Tick one.

◯ Sugar

◯ Starchy

◯ Fibre/ roughage

◯ Fat

◯ Not sure

20. Compared to minimally processed foods, processed foods are: (tick one)

◯ High in calories

◯ High in fibre

◯ Low in salt

◯ Not sure

Section 3: The next few items are about choosing foods.

21. If a person wanted to buy a yogurt at the supermarket, which would have the least sugar/sweetener? Tick one.

- ◯ 0% fat cherry yogurt
- ◯ Natural yogurt
- ◯ Creamy fruit yogurt
- ◯ Not sure

22. If a person wanted soup in a restaurant or cafe, which one would be the lowest fat option? Tick one.

- ◯ Mushroom risotto soup (field mushrooms, porcini mushrooms, arborio rice, butter, cream, parsley and cracked black pepper)
- ◯ Carrot butternut and spice soup (carrot , butternut squash, sweet potato, cumin, red chillies, coriander seeds and lemon)
- ◯ Cream of chicken soup (British chicken, onions, carrots, celery, potatoes, garlic, sage, wheat flour, double cream)
- ◯ Not sure

23. Which would be the healthiest and most balanced choice for a main meal in a restaurant? Tick one.

- ◯ Roast turkey, mashed potatoes and vegetables
- ◯ Beef, Yorkshire pudding and roast potatoes
- ◯ Fish and chips served with peas and tartar sauce
- ◯ Not sure

24. Which would be the healthiest and most balanced sandwich lunch? Tick one.

- ◯ Ham sandwich + fruit + blueberry muffin + fruit juice
- ◯ Tuna salad sandwich + fruit + low fat yogurt + water
- ◯ Egg salad sandwich + crisps + low fat yogurt + water
- ◯ Not sure

25. Which of these foods would be the healthiest choice for a pudding? Tick one.

- ◯ Berry sorbet
- ◯ Apple and blackberry pie
- ◯ Lemon cheesecake
- ◯ Carrot cake with cream cheese topping
- ◯ Not sure

26. Which of these combinations of vegetables in a salad would give the greatest variety of vitamins and antioxidants? Tick one.

- Lettuce, green peppers and cabbage
- Broccoli, carrot and tomatoes
- Red peppers, tomatoes and lettuce
- Not sure

27. If a person wanted to reduce the amount of fat in their diet, which chips would be the best choice to eat? Tick one.

- Thick cut chips
- Thin cut chips
- Crinkle cut chips
- Not sure

28. One healthy way to add flavour to food without adding extra fat or salt is to add: (tick one)

- Coconut milk
- Herbs
- Soya sauce
- Not sure

29. Which of the following cooking methods requires fat to be added? Tick one.

- Grilling
- Steaming
- Baking
- □□Sautéing
- Not sure

30. Traffic lights are often used on nutrition labelling, what would amber mean for the fat content of a food? Tick one.

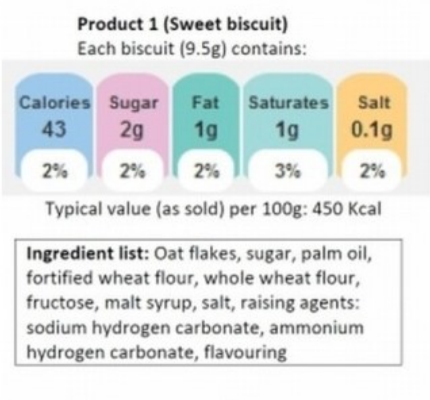
- Low fat
- Medium fat
- High in fat
- Not sure

31. "Light" foods (or Diet foods) are always good options because they are low in calories. Tick one.

- Agree
- Disagree
- Not sure

General Nutrition Knowledge Questionnaire - T2

The following questions are related to food labels:



32. Looking at products 1 and 2, which one has the most calories (kcal) per 100 grams? Tick one.

- ◯ Product 1
- ◯ Product 2
- ◯ Both have the same quantity
- ◯ Not sure

33. Looking at product 1, what are the sources of sugar in the ingredient list? Tick one.

- ◯ Sugar and malt syrup
- ◯ Sugar, fructose and lecithin
- ◯ Sugar, fructose and malt syrup
- ◯ Not sure

Section 4: This section is about health problems or diseases related to diet and weight management.

34. Which of these diseases is related to a low intake of fibre? Tick one.

- Bowel disorders
- Anaemia
- Tooth decay
- Not sure

35. Which of these diseases is related to how much sugar people eat? Tick one.

- High blood pressure
- Tooth decay
- Anaemia
- Not sure

36. Which of these diseases is related to how much salt (or sodium) people eat? Tick one.

- Hypothyroidism
- Diabetes
- High blood pressure
- Not sure

37. Which of these options do experts recommend to reduce the chances of getting cancer?Tick one.

- Drinking alcohol regularly
- Eating less red meat
- Avoiding additives in food
- Not sure

38. Which of these options do experts recommend to prevent heart diseases?Tick one.

- Taking nutritional supplements
- Eating less oily fish
- Eating less trans-fats
- Not sure

39. Which of these options do experts recommend to prevent diabetes?Tick one.

- Eating less refined foods
- Drinking more fruit juice
- Eating more processed meat
- Not sure

40. Which of the these foods is more likely to raise people's blood cholesterol? Tick one.

- Eggs
- Vegetable oils
- Animal fat
- Not sure

41. Which one of these foods is classified as having a high Glycaemic Index (Glycaemic Index is a measure of the impact of a food on blood sugar levels, thus a high Glycaemic Index means a greater rise in blood sugar after eating)? Tick one.

- ◯ Wholegrain cereals
- ◯ White bread
- ◯ Fruit and vegetables
- ◯ Not sure

42. To maintain a healthy weight people should cut fat out completely. Tick one.

- ◯ Agree
- ◯ Disagree
- ◯ Not sure

43. To maintain a healthy weight people should eat a high protein diet. Tick one.

- ◯ Agree
- ◯ Disagree
- ◯ Not sure

44. Eating bread always causes weight gain. Tick one.

- ◯ Agree
- ◯ Disagree
- ◯ Not sure

45. Fibre can decrease the chances of gaining weight. Tick one.

- ◯ Agree
- ◯ Disagree
- ◯ Not sure

46. Which of these options can help people to maintain a healthy weight? Answer each one.

	Yes	No	Not sure
Not eating while watching TV	◯	◯	◯
Reading food labels	◯	◯	◯
Taking nutritional supplements	◯	◯	◯
Monitoring their eating	◯	◯	◯
Monitoring their weight	◯	◯	◯
Grazing throughout the day	◯	◯	◯

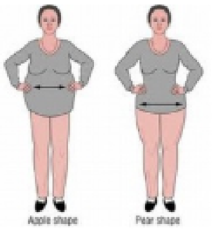
47. If someone has a Body Mass Index (BMI) of 23kg/m^2, what would their weight status be? Tick one.

- ◯ Underweight
- ◯ Normal weight
- ◯ Overweight
- ◯ Obese
- ◯ Not sure

48. If someone has a Body Mass Index (BMI) of 31kg/m^2, what would their weight status be? Tick one.

- Underweight
- Normal weight
- Overweight
- Obese
- Not sure

Look at the body image below:



49. Which of these body shapes increases the risk of cardiovascular disease (Cardiovascular disease is a general term that describes a disease of the heart of blood vessels, for example, angina, heart attack, heart failure, congenital heart disease and stroke)? Tick one.

- Apple shape
- Pear shape
- Not sure

Section 5: We would like to ask you a few questions about yourself.

50. What is your gender?

- Male
- Female
- Other (please specify)

51. What is your current weight approximately? Please give this in stones and pounds or kilograms.

Stones

Pounds

Or Kilograms

52. What is your current height approximately? Please give this in feet and inches or centimetres.

Feet

Inches

Or Centimetres

53. What is your current age?

54. At which University are you currently enrolled?

- Kingston University
- St George's University of London

55. At which Faculty are you enrolled?

- ◯ Art, Design and Architecture
- ◯ Arts and Social Sciences
- ◯ Business and Law
- ◯ Health, Social Care and Education
- ◯ Science, Engineering and Computing

If not sure, please name your school or course

56. What is your current studying status?

- ◯ Undergraduate student
- ◯ Postgraduate student

Other, please specify

57. Do you have any nutrition-related qualifications or are you studying to get a nutrition qualification?

- ◯ Yes
- ◯ No

If yes, please specify

58. What is your current living status?

- ◯ Living in student accommodation
- ◯ Sharing a house or flat other than student accomodation
- ◯ Living alone (in house/flat)
- ◯ Living with parent(s)/carer/family

Other (please specify)

59. What best describes your ethnic origin? Tick one.

- ◯ White British
- ◯ White Irish
- ◯ Other White background
- ◯ Black British
- ◯ Black Caribbean
- ◯ Black African
- ◯ Other Black background
- ◯ Indian
- ◯ Pakistani
- ◯ Bangladeshi
- ◯ Chinese
- ◯ Other Asian background
- ◯ White and Black Caribbean
- ◯ White and Black African
- ◯ White and Asian
- ◯ Arab
- ◯ Other mixed background

Other (please specify)

60. In general, how would you rate your health?

- ◯ Poor
- ◯ Fair
- ◯ Good
- ◯ Very good
- ◯ Excellent

61. Are you on a special diet?

- ◯ Yes
- ◯ No

If yes, please specify

62. Are you a current smoker?

- ◯ Yes
- ◯ No

Appendix I.C.ii Enumerated version of the General Nutrition Knowledge Questionnaire

GENERAL NUTRITION KNOWLEDGE QUESTIONNAIRE

This is a survey, not a test. Your answers will help identify which dietary advice people find confusing. It is important that you complete it by yourself. Your answers will remain anonymous. If you don't know the answer, mark "not sure" rather than guess. Thank you for your time.

Section 1: The first few items are about what advice you think experts are giving us.

1. Do health experts recommend that people should be eating more, the same amount, or less of the following foods? (tick one box per food)

		More	Same	Less	Not Sure
1.	Fruit	✓	☐	☐	☐
2.	Food and drinks with added sugar	☐	☐	✓	☐
3	Vegetables	✓	☐	☐	☐
4	Fatty foods	☐	☐	✓	☐
5	Processed red meat	☐	☐	✓	☐
6	Wholegrains	✓	☐	☐	☐
7	Salty foods	☐	☐	✓	☐
8.	Water	✓	☐	☐	☐

2. How many servings of fruit and vegetables per day do experts advise people to eat as a minimum? (One serving could be, for example, an apple or a handful of chopped carrots) (tick one)

	2	☐
	3	☐
9	4	☐
	5 or more	✓
	Not sure	☐

3. Which of these types of fats do experts recommend that people should eat less of? (tick one box per food)

		Eat less	Not eat less	Not sure
10	Unsaturated fats	☐	✓	☐
11	Trans fats	✓	☐	☐
12	Saturated fats	✓	☐	☐

4. Which type of dairy foods do experts say people should drink? (tick one)

	Full fat (e.g. full fat milk)	☐
	Reduced fat (e.g. skimmed and semi-skimmed milk)	✓
13	Mixture of full fat and reduced fat	☐
	Neither, dairy foods should be avoided	☐
	Not sure	☐

5. How many times per week do experts recommend that people eat oily fish (e.g. salmon and mackerel)? (tick one)

1-2 times per week ✓
3-4 times per week ☐
14 Every day ☐
Not sure ☐

6. Approximately how many alcoholic drinks is the maximum recommended per day (The exact number depends on the size and strength of the drink)? (tick one)

1 drink each for men and women ✓
2 drinks each for men and women ☐
15 2 drinks for men and 1 drink for women ☐
3 drinks for men and 2 drinks for women ☐
Not sure ☐

7. How many times per week do experts recommend that people eat breakfast? (tick one)

3 times per week ☐
4 times per week ☐
16. Every day ✓
Not sure ☐

8. If a person has two glasses of fruit juice in a day, how many of their daily fruit and vegetable servings would this count as? (tick one)

None ☐
One serving ✓
17. Two servings ☐
Three servings ☐
Not sure ☐

9. According to the 'eatwell guide' (a guideline showing the proportions of food types people should eat to have a balanced and healthy diet), how much of a person's diet should be made up of starchy foods? (tick one)

Quarter ☐
18 Third ✓
Half ☐
Not sure ☐

Section 2: Experts classify foods into groups. We are interested to see whether people are aware of food groups and the nutrients they contain.

1. Do you think these foods and drinks are typically high or low in added sugar? (tick one box per food)

		High in added sugar	Low in added sugar	Not sure
19	Diet cola drinks	☐	✓	☐
20	Natural yoghurt	☐	✓	☐
21	Ice cream	✓	☐	☐
22	Tomato ketchup	✓	☐	☐
23	Melon	☐	✓	☐

2. Do you think these foods are typically high or low in salt? (tick one box per food)

		High in salt	Low in salt	Not Sure
24	Breakfast cereals	✓	☐	☐
25	Frozen vegetables	☐	✓	☐
26	Bread	✓	☐	☐
27	Baked beans	✓	☐	☐
28	Red meat	☐	✓	☐
29	Canned soup	✓	☐	☐

3. Do you think these foods are typically high or low in fibre? (tick one box per food)

		High in fibre	Low in fibre	Not Sure
30	Oats	✓	☐	☐
31	Bananas	✓	☐	☐
32	White rice	☐	✓	☐
33	Eggs	☐	✓	☐
34	Potatoes with skin	✓	☐	☐
35	Pasta	☐	✓	☐

4. Do you think these foods are a good source of protein? (tick one box per food)

		Good source of protein	Not a good source of protein	Not sure
36	Poultry	✓	☐	☐
37	Cheese	✓	☐	☐
38	Fruit	☐	✓	☐
39	Baked beans	✓	☐	☐
40	Butter	☐	✓	☐
41	Nuts	✓	☐	☐

5. Which of the following foods do experts count as starchy foods? (tick one box per food)

		Starchy food	Not a starchy food	Not sure
42	Cheese	☐	✓	☐
43	Pasta	✓	☐	☐
44	Potatoes	✓	☐	☐
45	Nuts	☐	✓	☐
46	Plantains	✓	☐	☐

6. Which is the main type of fat present in each of these foods? (tick one box per food)

		Polyunsaturated fat	Monounsat-urated fat	Saturated fat	Cholesterol	Not sure
47	Olive oil	☐	✓	☐	☐	☐
48	Butter	☐	☐	✓	☐	☐
49	Sunflower oil	✓	☐	☐	☐	☐
50	Eggs	☐	☐	☐	✓	☐

7. Which of these foods has the most trans-fat? (tick one)

51

Biscuits, cakes and pastries	✓
Fish	☐
Rapeseed oil	☐
Eggs	☐
Not sure	☐

8. The amount of calcium in a glass of whole milk compared to a glass of skimmed milk is: (tick one)

52

About the same	✓
Much higher	☐
Much lower	☐
Not sure	☐

9. Which one of the following nutrients has the most calories for the same weight of food? (tick one)

53

Sugar	☐
Starchy	☐
Fibre/roughage	☐
Fat	✓
Not sure	☐

10. Compared to minimally processed foods, processed foods are: (tick one)

54

Higher in calories	✓
Higher in fibre	☐
Lower in salt	☐
Not sure	☐

Section 3: The next few items are about choosing foods

1. If a person wanted to buy a yogurt at the supermarket, which would have the least sugar/sweetener? (tick one)

0% fat cherry yogurt	☐
55 Natural yogurt	✓
Creamy fruit yogurt	☐
Not sure	☐

2. If a person wanted soup in a restaurant or cafe, which one would be the lowest fat option? (tick one)

Mushroom risotto soup (field mushrooms, porcini mushrooms, arborio rice, butter, cream, parsley and cracked black pepper)	☐
Carrot butternut and spice soup (carrot , butternut squash, sweet 56. potato, cumin, red chillies, coriander seeds and lemon)	✓
Cream of chicken soup (British chicken, onions, carrots, celery, potatoes, garlic, sage, wheat flour, double cream)	☐
Not sure	☐

3. Which would be the healthiest and most balanced choice for a main meal in a restaurant? (tick one)

Roast turkey, mashed potatoes and vegetables	✓
Beef, Yorkshire pudding and roast potatoes	☐
57. Fish and chips served with peas and tartar sauce	☐
Not sure	☐

4. Which would be the healthiest and most balanced sandwich lunch? (tick one)

Ham sandwich + fruit + blueberry muffin + fruit juice	☐
58. Tuna salad sandwich + fruit + low fat yogurt + water	✓
Egg salad sandwich + crisps + low fat yogurt + water	☐
Not sure	☐

5. Which of these foods would be the healthiest choice for a pudding? (tick one)

Berry sorbet	✓
Apple and blackberry pie	☐
59. Lemon cheesecake	☐
Carrot cake with cream cheese topping	☐
Not sure	☐

6. Which of these combinations of vegetables in a salad would give the greatest variety of vitamins and antioxidants? (tick one)

Lettuce, green peppers and cabbage ☐
Broccoli, carrot and tomatoes ✓
60 Red peppers, tomatoes and lettuce ☐
Not sure ☐

7. If a person wanted to reduce the amount of fat in their diet, but didn't want to give up chips, which of the following foods would be the best choice? (tick one)

Thick cut chips ✓
Thin cut chips ☐
61 Crinkle cut chips ☐
Not sure ☐

8. One healthy way to add flavour to food without adding extra fat or salt is to add: (tick one)

Coconut milk ☐
Herbs ✓
62 Soya sauce ☐
Not sure ☐

9. Which of the following cooking methods requires fat to be added? (tick one)

Grilling ☐
Steaming ☐
Baking ☐
63 Sautéing ✓
Not sure ☐

10. Traffic lights are often used on nutrition labelling, what would amber mean for the fat content of a food? (tick one)

Low fat ☐
Medium fat ✓
64 High in fat ☐
Not sure ☐

11. "Light" foods (or Diet foods) are always good options because they are low in calories. (tick one)

Agree ☐
65 Disagree ✓
Not sure ☐

The following questions are related to food labels:

Product 1 (Sweet biscuit)
Each biscuit (9.5g) contains:

Calories	Sugar	Fat	Saturates	Salt
43	2g	1g	1g	0.1g
2%	2%	2%	3%	2%

Typical value (as sold) per 100g: 450 Kcal

Ingredient list: Oat flakes, sugar, palm oil, fortified wheat flour, whole wheat flour, fructose, malt syrup, salt, raising agents: sodium hydrogen carbonate, ammonium hydrogen carbonate, flavouring

Product 2 (Savoury biscuit)
Each biscuit (16g) contains:

Calories	Sugar	Fat	Saturates	Salt
66	1g	3g	Trace	0.3g
3%	1%	4%	1%	4%

Typical value (as sold) per 100g: 412 Kcal

Ingredient list: Wheat Flour, Palm Oil, Corn Syrup, Malt, Salt, Yeast, Leavening Agents (Sodium Bicarbonate, Ammonium Bicarbonate, Sodium Pyrophosphate), Corn Starch, Soy Lecithin, Sodium Metabisulphite (Baking Agent).

12. Looking at products 1 and 2, which one has the most calories (kcal) per 100 grams (tick one)

Product 1 ✓
66 Product 2 ☐
Both have the same quantity ☐
Not sure ☐

13. Looking at product 1, what are the sources of sugar in the ingredient list? (tick one)

Sugar and malt syrup ☐
Sugar, fructose and lecithin ☐
67 Sugar, fructose and malt syrup ✓
Not sure ☐

Section 4: This section is about health problems or diseases related to diet and weight management

1. Which of these diseases is related to a low intake of fibre? (tick one)

Bowel disorders ✓
68. Anaemia ☐
Tooth decay ☐
Not sure ☐

2. Which of these diseases is related to how much sugar people eat? (tick one)

High blood pressure ☐
Tooth decay ✓
69 Anaemia ☐
Not sure ☐

3. Which of these diseases is related to how much salt (or sodium) people eat? (tick one)

Hypothyroidism ☐
Diabetes ☐
70 High blood pressure ✓
Not sure ☐

4. Which of these options do experts recommend to reduce the chances of getting cancer? (tick one)

Drinking alcohol regularly ☐
Eating less red meat ✓
71. Avoiding additives in food ☐
Not sure ☐

5. Which of these options do experts recommend to prevent heart disease? (tick one)

Taking nutritional supplements ☐
Eating less oily fish ☐
72. Eating less trans-fats ✓
Not sure ☐

6. Which of these options do experts recommend to prevent diabetes? (tick one)

Eating less refined foods ✓
73 Drinking more fruit juice ☐
Eating more processed meat ☐
Not sure ☐

13. Which of these options can help people to maintain a healthy weight? (answer each one)

		Yes	No	Not sure
80	Not eating while watching TV	✓	☐	☐
81	Reading food labels	✓	☐	☐
82	Taking nutritional supplements	☐	✓	☐
83	Monitoring their eating	✓	☐	☐
84	Monitoring their weight	✓	☐	☐
85	Grazing throughout the day	☐	✓	☐

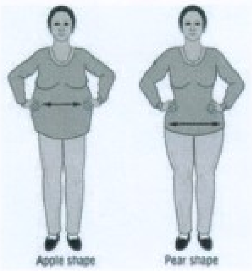
14. If someone has a Body Mass Index (BMI) of 23kg/m^2, what would their weight status be? (tick one)

Underweight ☐
Normal weight ✓
86 Overweight ☐
Obese ☐
Not sure ☐

15. If someone has a Body Mass Index (BMI) of 31kg/m^2, what would their weight status be? (tick one)

Underweight ☐
Normal weight ☐
87 Overweight ☐
Obese ✓
Not sure ☐

Look at the body shapes below:



16. Which of these body shapes increases the risk of cardiovascular disease (Cardiovascular disease is a general term that describes a disease of the heart of blood vessels, for example, angina, heart attack, heart failure, congenital heart disease and stroke)? (tick one)

Apple shape ✓
88 Pear shape ☐
Not sure ☐

Appendix I.D. Index of Diet Quality food frequency questionnaire (adapted from Leppälä et al., 2010)

Dietary Habits Questionnaire - T1

Whole grain products

2. How many slices of bread and/or bread rolls do you eat per day?

Slices of bread ______

Bread rolls ______

3. The bread you eat usually is? Tick one.

- ○ Rye bread or crisp bread (rye crisp)
- ○ Whole-grain bread
- ○ White bread
- ○ I don't eat bread

4. How many days per week do you eat whole-grain products (for example bread, porridge, muesli)?

Days a week ______

Fat containing foods

5. The type of spread you usually use with bread is?

- ○ None
- ○ Spread with max 40% fat (e.g. low fat or light spreads with vegetable oils such as olive oil or rapeseed oil)
- ○ Spread with max 60% fat (e.g. vegetable oils spreads)
- ○ Spread with max 70%-80% fat (e.g. blended fat spread with vegetable oils)
- ○ Butter-vegetable oil-mix (e.g. spreadable butter)
- ○ Butter
- ○ Plant sterol margarine

6. The type of salad dressing you usually use is?

- ○ Vegetable oil-based dressing
- ○ Light cream-based
- ○ Mayonnaise
- ○ Light dressing
- ○ I don't use salad dressings

7. How many days per week do you eat fish?

Days a week ______

8. The milk you usually drink is:

- ○ Whole milk or full-fat milk (3.5% fat)
- ○ Semi-skimmed milk (1.5-1.8% fat) or almond milk or soya milk
- ○ Milk with 1% fat
- ○ Skimmed milk (less than 0.3% fat)
- ○ I don't drink milk

Dairy products

9. How many days per week do you consume dairy products (e.g. milk, yogurt, hard or cheese, ice-cream, soured cream)?

Days a week

10. How many portions of liquid dairy products, such as milk, smoothies, protein milkshakes or yogurt drinks, do you consume on those days? (1 portion is equal to 200mL)

Portions per day

Vegetables, fruits and berries

11. How many days per week do you eat vegetables?

Days a week

12. How many portions of vegetables do you consume on those days?
(1 portion is equal to 1 medium tomato or 2 broccoli spears or 4 heaped tablespoons of cooked kale/spinach or 3 heaped tablespoons of cooked carrots/peas/sweet corn)

Portions per day

13. How many days per week do you eat fruits and/or berries?

Days a week

14. How many portions of fruits and/or berries do you consume on those days?
(1 portion is equal to 2 small-sized fruits such as plums, or 1 medium-sized fruit such as apple, or half of a large fruit such as grapefruit, or 1 slice of fruit such as melon, or 1 heaped tablespoon of dried fruits such as raisins or 4 heaped tablespoons of berries)

Portions per day

Sugar

15. How many days per week do you drink fruit juices?

Days per week

16. How many portions of fruit juices do you drink on those days? (1 portion is equal to 150mL)

Portions per day

17. How many days per week do you drink soft drinks with sugar (including energy drinks)?

Days per week

18. How many days per week do you eat sweets (including chocolate)?

Days per week

Meal pattern

19. How many days per week do you skip breakfast, lunch or dinner?

Days per week

Alcohol

20. How many days per week do you drink alcohol?

Days per week

21. When you consume alcohol, how many drinks do you usually have per occasion? (1 drink is equal to 1 glass of wine, or a bottle or a can of beer or a shot glass of spirits or a mixed drink)

Drinks per occasion

Appendix I.E. The International Physical Activity Questionnaire (Short-Form) (adapted from Craig et al., 2003)

International Physical Activity Questionnaire - T1

Vigorous physical activities

Think about all the **vigorous activities** that you did **in the last 7 days**. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

2. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

- No vigorous physical activities
- 1 day/week
- 2 days/week
- 3 days/week
- 4 days/week
- 5 days/week
- 6 days/week
- 7 days/week

3. How much time did you usually spend doing vigorous physical activities on one of those days?

Hours per day

Minutes per day

Write "NS" in this box if you don't know or are not sure

Moderate Physical Activities

Think about all the **moderate activities** that you did **in the last 7 days**. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

4. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

- No moderate physical activities
- 1 day/week
- 2 days/week
- 3 days/week
- 4 days/week
- 5 days/week
- 6 days/week
- 7 days/week

5. How much time did you usually spend doing moderate physical activities on one of those days?

Hours per day

Minutes per day

Write "NS" in this box if you don't know or are not sure

Walking

Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

6. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

- ◯ No walking
- ◯ 1 day/week
- ◯ 2 days/week
- ◯ 3 days/week
- ◯ 4 days/week
- ◯ 5 days/week
- ◯ 6 days/week
- ◯ 7 days/week

7. How much time did you usually spend walking on one of those days?

Hours per day	
Minutes per day	
Write "NS" in this box if you don't know or are not sure	

Sitting time

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television. It does not include sleeping.

8. During the last 7 days, how much time did you spend sitting on a week day?

Hours per day	
Minutes per day	
Write "NS" in this box if you don't know or are not sure	

Appendix I.F. Questionnaire to assess students' perceptions regarding the e-programme (Evaluation study)

English (United Kingdom) ▾

SURVEY INSTRUCTIONS

Introduction.
Dear student,

Thank you for your time to complete the following online survey, which will take approximately 5-10 minutes.

The survey includes questions with multiple choices answers and questions where you can write and expand your thoughts. Your responses will help us get a better insight of the online educational programme and design better ones in the future.

The survey is confidential and you can withdraw at any time by exiting the questionnaire. Before you start, you need to declare your consent to enter the survey.

Information Sheet. Please, first read the participant information sheet of the survey.

Information for participants

Consent. I declare my consent to participate in the online survey.

- ○ Accept
- ○ Decline

Q1. To what extent do you agree with the following statements with regards to the information you received about the study in the beginning?

	Disagree	Somewhat disagree	Somewhat agree	Agree
The information provided prior to the start of the programme was useful and clear.	○	○	○	○
I was aware of what I was expected to do as a participant in the programme.	○	○	○	○
I could contact the lead investigator of the programme at any time for clarification or any other reason.	○	○	○	○

Q2. To what extent did you feel motivated to undertake the study in the beginning? (choose one answer)

- ○ Not motivated
- ○ Somewhat motivated
- ○ Motivated
- ○ Very motivated

Q3.
What was the main reason for taking part in the study?

Q4. To what extent do you agree with the following statements with regards to the measures undertaken in the beginning and at the end of the study?

	Disagree	Somewhat disagree	Somewhat agree	Agree
Measuring body composition (weight, fat, lean mass, etc.) was helpful to learn about my health.	○	○	○	○
Measuring blood pressure or/and blood glucose was helpful to learn about my health.	○	○	○	○
Counting steps was helpful to realise how much I walk.	○	○	○	○

Q5. What other measures would you like to have been undertaken as part of the study?

Q6. Which components of the online educational programme did you like? (you can choose more than one answer)

- ☐ The website
- ☐ The quiz-games

Q7. To what extent do you agree with the following statements with regards to the topics chosen to be included in the online educational programme?

	Disagree	Somewhat disagree	Somewhat agree	Agree
I liked that information about activity and exercise was included.	○	○	○	○

	Disagree	Somewhat disagree	Somewhat agree	Agree
I liked that information about alcohol was included	○	○	○	○
I liked that information about fast-food was included	○	○	○	○
I liked that information about fats was included	○	○	○	○
I liked that information about food labels was included	○	○	○	○
I liked that information about fruit and vegetables was included	○	○	○	○
I liked that information about meals and snacks was included	○	○	○	○
I liked that information about meat was included	○	○	○	○
I liked that information about salt was included	○	○	○	○
I liked that information about sugars, and sugary drinks was included	○	○	○	○
I liked that information about how to eat on a budget was included	○	○	○	○
I liked that information about body weight was included.	○	○	○	○

Q8. Which other topics would you have liked to have been included?

Q9. Which of the following topics of the educational website did you visit? (You can choose more than one answer)

- ☐ Activity and exercise
- ☐ Alcohol
- ☐ Fast-food
- ☐ Fats
- ☐ Food-labels
- ☐ Fruit and vegetables
- ☐ Meals and snacks
- ☐ Meat
- ☐ Salt
- ☐ Sugars and sugary drinks
- ☐ Eating on a budget
- ☐ Body weight

Q10. Which of the following quiz-games of the online programme did you play? (You can choose more than one answer)

- ☐ Activity and exercise
- ☐ Alcohol
- ☐ Fast-food
- ☐ Fats
- ☐ Food-labels
- ☐ Fruit and vegetables
- ☐ Meals and snacks
- ☐ Meat
- ☐ Salt
- ☐ Sugars and sugary drinks

Q11. To what extent do you feel that the online programme had an impact on your better understanding the following topics?

	No impact	Minor impact	Moderate impact	Major impact
Activity and exercise	O	O	O	O
Alcohol	O	O	O	O
Fast-food	O	O	O	O
Fats	O	O	O	O
Food labels	O	O	O	O
Fruit and vegetables	O	O	O	O

	No impact	Minor impact	Moderate impact	Major impact
Meals and snacks	O	O	O	O
Meat	O	O	O	O
Salt	O	O	O	O
Sugars and sugary drinks	O	O	O	O
Eating on a budget	O	O	O	O
Body weight	O	O	O	O

Q12. To what extent do you agree with the following statements regarding the amount of information provided through the online programme for each topic?

	Disagree	Somewhat disagree	Somewhat agree	Agree
The amount of information provided about activity and exercise was adequate	O	O	O	O
The amount of information provided about alcohol was adequate	O	O	O	O
The amount of information provided about fast-food was adequate	O	O	O	O
The amount of information provided about fats was adequate	O	O	O	O
The amount of information provided about food labels was adequate	O	O	O	O
The amount of information provided about fruit and vegetables was adequate	O	O	O	O
The amount of information provided about meals and snacks was adequate	O	O	O	O
The amount of information provided about meat was adequate	O	O	O	O
The amount of information provided about salt was adequate	O	O	O	O
The amount of information provided about sugars and sugary drinks was adequate	O	O	O	O

Q13. To what extent do you feel that the following information found on the website were valuable?

	Not valuable	Somehow valuable	Valuable	Very valuable
Information on how foods/drinks intake or exercise could impact health	○	○	○	○
Information about portion sizes and recommended servings (foods, alcohol, etc.)	○	○	○	○
Tips and advice to improve eating and physical activity habits.	○	○	○	○

Q14. What other information would you have liked to have been included in each topic?

Q15. To what extent do you agree with the following statements with regards to the characteristics of the online programme?

	Disagree	Somewhat disagree	Somewhat agree	Agree
The programme was easily accessed	○	○	○	○
The delivery of the programme online was an appropriate approach	○	○	○	○
The programme had a good duration	○	○	○	○
The programme provided flexibility	○	○	○	○
The time needed for the programme was bearable	○	○	○	○
Overall the programme was informative and useful	○	○	○	○

	Disagree	Somewhat disagree	Somewhat agree	Agree
The programme could be easily implemented within university	○	○	○	○
I would recommend my friends to engage in this programme	○	○	○	○
I would participate in similar programmes in the future	○	○	○	○
Participating in the programme was a good use of my time.	○	○	○	○

Q16. What other features would you recommend to improve the specific online educational programme?

Q17. What other online tools or technology-based methods would you like the university to implement to increase awareness about healthy eating and physical activity among students?

Q18. Besides online or technology-based methods, what other programmes or actions would you like the university to accommodate to increase awareness about healthy eating and physical activity among students?

Q19. Add here any thoughts or ideas you would like to express in relation to the above.

Thank you for your time

Appendix II. Supplementary material of the Overview (Chapter 4)

Appendix II.A. Search Strategy in Pubmed

((((intervention?[Text Word]) OR intervention*[Other Term]) AND (((((((((((((((((nutrition[MeSH Terms]) OR ((nutrition[Text Word]) OR nutrition[Other Term])) OR diet[MeSH Terms]) OR ((diet?[Text Word]) OR diet*[Other Term])) OR ((((((((food habits[Text Word]) OR food habits[Other Term]) OR dietary habits[Text Word]) OR dietary habits[Other Term]) OR eating habits[Text Word]) OR eating habits[Other Term]) OR dietary intake?[Text Word]) OR dietary intake*[Other Term])) OR physical activity[MeSH Terms]) OR exercise[MeSH Terms]) OR ((((physical activity[Text Word]) OR physical activity[Other Term]) OR exercise[Text Word]) OR exercise[Other Term])) AND university[MeSH Terms]) OR ((((university[Text Word]) OR university[Other Term]) OR college[Text Word]) OR college[Other Term])) AND ((Review[ptyp] OR systematic[sb])))) NOT patients[Title/Abstract]) NOT hospital[Title/Abstract]) AND ((Review[ptyp] OR systematic[sb])))) NOT children[MeSH Terms]) AND ((Review[ptyp] OR systematic[sb])))) AND ((Review[ptyp] OR systematic[sb])))) AND ((Review[ptyp] OR systematic[sb])))) AND English[Language] Filters: Review; Systematic ReviewsFilters: Review, Systematic Reviews.

Appendix II.B. Environmental interventions

Supplemental table 1. Brief description of environmental interventions targeting dietary and weight-related outcomes in university students, reviews including them and number of improved/not improved outcomes as appear in reviews[1]

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Food sales (n=number of outcomes)		Other outcomes (n=number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Information through labelling and other signage						
Aaron et al. (S1)	Christoph & An (20) Lua & Wan (23)	POP information through nutrition labelling		**Intakes: n=2** (total energy and fat intake increased)		
Bergen & Yeh (S2)	Roy et al. (21)	Nutrition information through labelling and posters on vending machines	**Sales: n=2** (lower growth rate sales of sugary-beverages; increased sales of all beverages, mostly of water)			
Buscher et al. (2 studies) (S3)	Deliens et al. (18) Roy et al. (21) Kelly et al. (22)	POP information through posters and other signage	**Sales: n=4** (increased sales of yogurt, pretzels, whole fruit, packaged salads)	**Sales: n=3** (not increases in sales of fruit baskets and vegetables baskets; increases in sales of candy)		
Chu et al. (S4)	Christoph & An (20) Roy et al. (21)	POP information through nutrition labelling	**Sales: n=1** (reduced average energy content of entrées sold)	**Sales: n=1** (not change in total number of entrées sold)		
Cioffi et al. (S5)	Christoph & An (20)	POP information through nutrition labelling	**Sales: n=4** (decreased mean energy and fat content of items sold; sales of low calorie-foods increased; sales of high-fat foods decreased)			
Cranage et al. (S6)	Roy et al. (21)	POP nutrition information on laminated cards	**Sales: n=2** (decreases in sales of high-fat/high-		**Other: n=2** (higher rating of food	

[1] FVI: Fruit and Vegetable Intake; NC: information Not Clear; POP: Point-of-Purchase

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Food sales (n=number of outcomes)		Other outcomes (n=number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Information through labelling and other signage						
			calorie entrées; increases in sales of low-fat/ low-calorie entrées)		quality satisfaction; higher intention to repurchase)	
Davis-Chervin et al. S(7)	Christoph & An (20)	POP nutrition information displayed on posters and cards	**Sales: n=2** (low calorie entrees; low-cholesterol entrees)	**Sales: n=1** (low-fat entrees not increased)		
Dingman et al. (S8)	Christoph & An (20)	Nutrition information on labels/posters on vending machines		**Sales: n=2** (average calories per snack, proportion of targeted snacks sold)		
Driskell et al. (S9)	Roy et al. (21)	POP information through nutrition labelling	NC			
Christoph & Ellison (S10)	Christoph & An (20)	Nutrition information signage (caloric content, traffic lights) on specific menus	**Sales: n=2** (medium and low-calorie entrees increased; high-calorie items decreased)			
Freedman (S11)	Christoph & An (20)	POP information through nutrition labelling, laminated signs, and photos	**Sales: n=1** (% of students choosing large portions of French fries decreased)	**Sales: n=2** (% of students choosing salad dressing and French fries did not decrease)		
Freedman & Connors (S12)	Christoph & An (20) Deliens et al. (18) Roy et al. (21) Kelly et al. (22)	POP information through nutrition labelling		**Sales: n=4** (cereal, soup, cracker and bread not increased)		
Hammond et al. (S13)	Christoph & An (20)	POP information through nutrition labelling	**Intakes: n=2** (calories ordered and consumed decreased)			
Hoefkens et al. (S14)	Christoph & An (20) Roy et al. (21)	POP nutrition information through signage (star rating point system, posters)	**Intakes: n=1** (increased vegetable intake)	**Sales: n=1** (targeted meals not increased) **Intakes: n=4** (energy, fat, saturated fat, and sodium intakes not decreased)		
Hoerr & Louden (S15)	Christoph & An (20)	Nutrition information using posters on vending machines		**Sales: n=3** (low-nutrient density snacks not decreased; moderate and		

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Food sales (n=number of outcomes)		Other outcomes (n=number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Information through labelling and other signage						
				high-nutrient density snacks not increased)		
James et al. (S16)	Christoph & An (20)	Labels with nutrition and exercise information on specific menus	**Sales: n=1** (fewer calories ordered) **Intakes: n=2** (energy and fat intake decreased)			
Kolodinsky et al. (S17)	Plotnikoff et al. (26)	POP information through nutrition labelling	NC	NC		
Larson-Brown (S18)	Christoph & An (20)	Information through nutrition labelling on vending machines	**Sales: n=1** (sales of more-nutritious food increased)	**Sales: n=1** (sales of less-nutritious foods not decreased)		
Lillico et al. (S19)	Christoph & An (20)	POP information through nutrition labelling		**Intakes: n=1** (calorie intake not decreased)		
Nikolaou et al. (S20)	Christoph & An (20) Roy et al. (21)	POP information through nutrition labelling and posters	**Intakes: n=3** (calories, fat and saturated fat content of selected meals decreased)	**Intakes: n=3** (vitamin C, iron and calcium did not increase)	**Other: n=1** (prevention of weight gain)	
Nikolaou et al. (S21)	Christoph & An (20)	POP information through nutrition labelling	**Sales: n=2** (sales of high-calorie and high-fat sandwiches decreased)	**Sales: n=2** (sales of low-calorie and low-fat sandwiches decreased)		
Peterson et al. (S22)	Deliens et al. (18) Roy et al. (21) Plotnikoff et al. (26) Kelly et al. (22)	POP nutrition information through signage (indicators, signs, table tents, flyers, photographs)	**Intakes: n=3** (increased intakes of cottage cheese, low-fat salad dressing; decreased intake of deli sandwiches)	**Intakes: n=7** (not increased intakes of grilled chicken breast, tossed salad, steamed vegetables, fresh fruits, yoghurt, skim milk, whole grain bread)		
Reed et al. (S23)	Deliens et al. (18) Plotnikoff et al. (26)	POP nutrition information using PowerPoint slides	**Intakes: n=1** (increased fruit intake)	**Intakes: n=1** (no reduction in cookie intake)		
Roy et al. (S24)	Christoph & An (20)	POP information through nutrition labelling	**Sales: n=2** (sales of two targeted items changed favorably	**Sales: n=7** (sales of seven targeted items did not change)		
Schwartz et al. (S25)	Christoph & An (20)	POP information through nutrition labelling		**Sales: n=1** (calories ordered did not		

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Food sales (n=number of outcomes)		Other outcomes (n=number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Information through labelling and other signage						
				decrease)		
Temple et al. (S26)	Christoph & An (20)	POP information through nutrition labelling plus educational video before lunchtime	**Intakes: n=2** (energy intake reduced; not increases in intake of high-energy-dense foods)	**Intakes: n=1** (control group increased intake of low-energy-density foods)		
Temple et al. (2 studies) (S27)	Christoph & An (20)	Nutrition labelling on menus	**Intakes: n=2** [increased intake of green (healthier) foods; decreased intake of red (less healthy) foods]	**Intakes: n=1** (energy intake did not decrease)		
Turconi et al. (S28)	Roy et al. (21)	POP nutrition information through pyramid figures	NC	NC		
Total number of outcomes			Total: 40 Food sales: 24 Dietary intakes: 16	Total: 48 Food sales: 28 Dietary intakes: 20	Total: 3	
Increasing availability of targeted items, controlling portion size or providing price incentives						
Cardenas et al. (S29)	Deliens et al. (18)	Three phases: 1) POP information, 2) POP information plus health and price information, 3) POP information plus price reduction		**Sales: n=1** (no increased fruit sales)		
Cinciripini (S30)	Christoph & An (20)	Cash rebate, caloric feedback of food selections, nutrition information (labels, flyer distribution)	**Sales: n=6** (starchy carbohydrates; red meat; regular dairy; high fat dessert/sauces decreased. Salad; and non-starchy vegetable/soup/fruit/low-fat dairy increased for subgroups)			
Freedman & Brochado (S31)	Roy et al. (21)	Portion control (reduce portion size)	**Intakes: n=1** (reduced intakes of French fries)			
McClain et a. (S32)	Deliens et al. (18)	Marketing campaign (sample plates, signage, table tents, flyers, photographs)	**Intakes: n=2** (decreases in high-fat meat and junk food intakes)	**Intakes: n=2** (no increases in FVI, no reductions in high-fat dairy intakes)		
Michels et al. (S33)	Roy et al. (21)	POP information (nutrition labels) and price reductions	**Sales: n=2** (increases in sales of healthy foods; decreases in sales of less-healthy foods)			

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Food sales (n=number of outcomes)		Other outcomes (n=number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Information through labelling and other signage						
Lachat et al. (S34)	Roy et al. (21)	Free distribution of targeted items (fruit and vegetables)	**Intakes: n=1** (Increased FVI)	**Intakes: n=3** (no reduced energy, fat, and sodium intake)		
Shive & Morris (S35)	Roy et al. (21) Laska et al. (25)	Increased availability of targeted foods plus information (nutrition labels, fairs)	**Intakes: n=1** (increased fruit intake)	NC		
Stroebele et al. (36)	Roy et al. (21)	Portion control (reduce portion of snacks)	**Intakes: n=1** (decreased snack intake)			
Total number of outcomes			Total: 14 Food sales: 8 Dietary intakes: 6	Total: 6 Food sales: 1 Dietary intakes: 5		
Overall number of outcomes of all interventions			**Overall: 54** **Foods sales: 32** **Dietary intakes: 22**	**Overall: 54** **Food sales: 29** **Dietary intakes: 25**	**Other: 3**	

Appendix II.C. Face-to-face interventions

Supplemental table 2. Brief description of face-to-face interventions targeting dietary, physical activity and weight-related outcomes in university students, reviews including them, and number of improved/not improved outcomes appear in reviews[2]

Study	Reviews including the study	Brief description of intervention	**Dietary intakes/ Diet cognitive** (n= number of outcomes)		**Physical activity behaviour/PA cognitive** (n= number of outcomes)		**Weight-related** (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
In-class interventions								
Abood et al. (S37)	Lua & Wan (23)	In-class educational sessions with activities	**Intakes: n=1** (overall number of positive dietary changes increased) **C-diet: n=2** (nutrition knowledge and self-efficacy increased)					
Abu-Moghli et al. (S38)	Plotnikoff et al. (26)	Educational workshops	**Intakes: n=2** (type of diet score increased; overall dietary habits scored increased)			**PA behaviour: n=1** (activity score of did not increase)		
Afifi Soweid et al (S39)	Plotnikoff et al. (26)	In class-educational course with activities	NC		NC		NC	
Alpar et al. (S40)	Plotnikoff et al. (26)	Educational (nursing) program		**Intake: n=1** (frequency of healthy eating score did not increase)	**PA behaviour: n=1** (frequency of exercise score increased)			
Calfas et al. (S41)	Laska et al. (25)	In-class educational course				NC		

[2]C-diet: Cognitive Dietary outcomes; C-PA: Cognitive Physical Activity outcomes; FVI: Fruit and Vegetable Intake; MET: Metabolic Task Equivalent; MPA: Moderate Physical Activity; NC: information Not Clear; PA: Physical Activity; VPA: Vigorous Physical Activity; WHR: Waist-to-Hip Ratio; WR: Weight-related outcomes

Study	Reviews including the study	Brief description of intervention	**Dietary intakes/ Diet cognitive** (n= number of outcomes)		**Physical activity behaviour/PA cognitive** (n= number of outcomes)		**Weight-related** (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Cardinal et al. (S42)	Plotnikoff et al. (26) Laska et al. (25)	In-class educational course and lab activities			NC			
Chen et al. (S43)	Plotnikoff et al. (26)	In-class educational course with activities	NC					
Claxton et al. (S44)	Maselli et al. (24) Plotnikoff et al. (26) Laska et al. (25)	In-class course with homework			**PA behaviour: n=1** (days of activity for weight management increased)	**PA behaviour: n= 4** (MPA; VPA; strength/endurance activity; flexibility activity not increased)		
DeVahl et al. (S45)	Laska et al. (25)	In-class course with activities plus course bonus award					**WR: n=1** (body fat not decreased)	
Endevelt et al. (S46)	Lua & Wan (23)	In-class workshop with interactive activities	NC					
Finckenor & Byrd-bredbenner (S47)	Laska et al. (25)	Group-based short course	NC					
Ince (S48)	Plotnikoff et al. (26)	In-class educational course with activities plus exercise at the gym	**Intakes: n=1** (nutrition behaviour score increased)		**PA behaviour: n=4** [exercise score increased; MPA, VPA and total PA (MET-min/week) increased]	**PA behaviour: n=1** [walking (MET-min/week) did not increase]		
Jung & Heald (S49)	Laska et al. (25)	In-class instructor-delivered lecture involving high-intender/ low-intender discriminate beliefs				NC		
Hall & Fong (S50)	Maselli et al. (24)	Educational fitness classes with or no goal setting			**PA behaviour: n=1** (weekly VPA increased at post-test but did not maintain at follow-up)	**PA behaviour: n=5** (monthly VPA did not increase; weekly minutes of MPA, very hard PA, strength and flexibility activity did		

Study	Reviews including the study	Brief description of intervention	Dietary intakes/ Diet cognitive (n= number of outcomes)		Physical activity behaviour/PA cognitive (n= number of outcomes)		Weight-related (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
						not increase)		
Gieck & Olsen (S51)	Plotnikoff et al. (26)	In-class educational course				**C-PA: n=2** (knowledge and self-efficacy of physical wellness did not increase)		
Gray et al. (S52)	Plotnikoff et al. (26)	In-class educational course		NC				
Ha et al. (S53)	Kelly et al. (22) Lua & Wan (23) Laska et al. (25)	In-class educational course with interactive activities	**Intakes: n=3** (soft-drinks reduced; fat-free milk increased; whole-milk decreased)	**Intakes: n=1** (low-fat milk decreased)				
Ha & Caine-Bish N (S54)	Plotnikoff et al. (26) Kelly et al. (22) Lua & Wan (23) Laska et al. (25)	In-class educational course with interactive activities	**Intakes: n=5** (total & fresh vegetable increased; total & fresh fruit increased; French fries decreased)	**Intakes: n= 4** (starchy vegetables; vegetable juice; fruit juice; canned fruits not increased)				
Ha & Caine-Bish (S55)	Kelly et al. (22) Lua & Wan (23) Laska et al. (25)	In-class educational course with interactive activities	**Intakes: n=1** (whole grains increased) **C-diet: n=1** (whole-grain knowledge increased)					
Hager et al. (S56)	Plotnikoff et al. (26)	In-class (vs the same online) educational course with assignments	**Intakes: n=3** (fruit & vegetable; bran/wholegrain cereals; brown rice/ whole wheat foods increased)	**Intakes: n=1** (green salad did not increase)	**PA behaviour: n=4** (days of MPA; minutes of MPA; overall PA and VO_2 max increased)	**PA behaviour: n=2** (frequency and length of VPA did not increase)		**WR: n=2** (BMI and body mass did not improve)
Hekler et al. (S57)	Plotnikoff et al. (26) Kelly et al. (22) Laska et al. (25)	Group-based educational course with interactive activities	**Intakes: n=2** (vegetables increased; high-fat dairy decreased)	**Intakes: n=4** (fruit did not increase; high-fat meats, sweets, processed foods did not decrease)				
Hivert et al. (S58)	Maselli et al. (24)	Group-based educational				**PA behaviour: n=1** (total PA did not	**WR: n=2** (BMI and body	

Study	Reviews including the study	Brief description of intervention	Dietary intakes/ Diet cognitive (n= number of outcomes)		Physical activity behaviour/PA cognitive (n= number of outcomes)		Weight-related (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
	Laska et al. (25)	seminars				increase)	mass decreased)	
Kozak et al. (S59)	Masselli et al. (24)	Group-based informative and exercise instructive sessions with framed messages				**PA behaviour: n=2** (MVPA and strength activity did not increase)		
Matvienko et al. (S60)	Deliens et al. (18) Lua & Wan (23) Laska et al. (25)	In-class educational course		**Intakes: n=4** (energy and fat intake did not decrease; protein and carbohydrate intake did not change)			**WR: n= 2** (body mass and BMI did not change)	
Mitchell (S61)	Laska et al. (25)	In-class educational course	NC					
Ng et al. (S62)	Masselli et al. (24)	In-class educational course with activities				**PA behaviour: n=3** (no increase in weekly minutes of LPA, MPA and VPA) **C-PA: n=3** (perceived self-efficacy, motives and barriers toward exercise did not improve)		
Pearce & Cross (S63)	Plotnikoff et al. (26)	In-class educational course with activities	**C-diet: n=5** (knowledge of dietary recommendations, sources of nutrients, healthy food choices, diet-disease relationships and overall score increased)					
Pearman et al. (S64)	Plotnikoff et al. (26)	In-class educational course	**Intakes: n= 5** (energy, fat, sodium, and cholesterol intakes decreased; carbohydrate intake	**Intakes: n=4** (protein, calcium, iron, fiber did not change)	**PA behaviour: n=1** (frequency of jogging/running increased)	**PA behaviour: n=4** (frequency of doing sports; physical exercise; swimming/walking;		

Study	Reviews including the study	Brief description of intervention	**Dietary intakes/ Diet cognitive** (n= number of outcomes)		**Physical activity behaviour/PA cognitive** (n= number of outcomes)		**Weight-related** (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
			increased)			gardening/fishing/hunting did not increase)		
Schnoll & Zimmerman (S65)	Kelly et al. (22)	In-class course with different assignments (goal setting vs self-monitoring)	**C-diet: n=3** (knowledge, goal-setting and self-monitoring of fiber intake increased)					
Skinner (S66)	Laska et al. (25)	In-class educational course	NC					
Stice et al. (S67)	Laska et al. (25)	Group-based psycho-educational seminars with assignments					**WR: n= 1** (BMI remained unchanged in contrast to control group)	
Total number of outcomes			Total: 34 Dietary intakes: 23 C-diet: 11	Total: 19 Dietary intakes: 19 C-diet: -	Total: 12 PA behaviour: 12 C-PA: -	Total: 28 PA behaviour: 23 C-PA: 5	Total WR: 6	Total WR: 2
Tailored interventions								
Bowden et al. (S68)	Plotnikoff et al. (26)	Tailored diet and activity prescription		**Intakes: n=1** (systemic glycose level did not reduce)				
Brinberg et al. (S69)	Laska et al. (25)	Tailored (vs general) motivational messages with feedback	NC					
Buscemi et al. (S70)	Plotnikoff et al. (26)	Tailored brief motivational consultation plus boost phone call		**Intakes: n=5** (fruit, vegetables did not increase; sweets, fast-food and sugary beverages did not decrease)		**PA behaviour: n=2** (VPA and MPA did not increase)		**WR: n=2** (BMI and body mass did not decrease)
Martens et al. (S71)	Maselli et al. (24) Plotnikoff et al. (26)	Tailored Brief Motivational Consultation			**PA behaviour: n=2** (weekly days and minutes of VPA increased)	**PA behaviour: n=2** (weekly days and minutes of MPA did not increase)		
Werch et al. (S72)	Plotnikoff et al.	Tailored	**Intakes: n=1**	**Intakes: n=2**	**PA behaviour: n=3**	**PA behaviour: n=2**		

Study	Reviews including the study	Brief description of intervention	Dietary intakes/ Diet cognitive (n= number of outcomes)		Physical activity behaviour/PA cognitive (n= number of outcomes)		Weight-related (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
	(26)	consultation plus contract with calendar log	(foods with healthy fats increased)	(FVI and foods with healthy carbohydrates did not increase)	(length of exercise; monthly and weekly MPA)	(monthly VPA and weekly strenuous activity did not increase)		
Werch et al. (S73)	Maselli et al. (24) Deliens et al. (18) Plotnikoff et al. (26) Kelly et al. (22)	Tailored brief image-based multiple-behaviour intervention		**Intakes: n=3** (FVI; foods with healthy carbohydrates and foods with healthy-fats did not increase)		**PA behaviour: n=5** (length of exercise; monthly VPA; monthly MPA; weekly strenuous PA; weekly MPA did not increase)		
Werch et al. (follow-up study) (S74)	Maselli et al. (24)	Tailored brief image-based multiple-behaviour intervention			**PA behaviour: n=1** (smaller decrease in monthly MPA compared to control group)			
You et al. (S75)	Lua & Wan (23)	Tailored prescriptions plus supplement plus educational program					**WR: n=4** (body mass, BMI, body fat and WHR reduced)	
Total number of outcomes			Total: 1 Dietary intakes: 1 C-diet: -	Total: 11 Dietary intakes: 11 C-diet: -	Total: 6 PA behaviour: 6 C-PA: -	Total: 11 PA behaviour: 11 C-PA: -	Total WR: 4	Total WR: 2
Peer-training interventions								
Fischer & Bryant (S76)	Plotnikoff et al. (26)	Peer training (pesronal training provided by certified students)				**C-PA: n=5** (cognitive and behavioural process of change; decisional balance; coping, scheduling, and task self-efficacy did not improve)		
King et al. (S77)	Plotnikoff et al. (26)	Peer-training	**Intakes: n=1** (FVI increased) **C-diet: n= 1** (perceived FVI planning increased)	**C-diet: n=1** (perceived health benefits of FVI did not increase)	**C-PA: n=1** (perceived exercise barriers decreased)	**PA behaviour: n=1** (sedentary behaviour decreased) **C-PA: n=1** (perceived health		

Study	Reviews including the study	Brief description of intervention	Dietary intakes/ Diet cognitive (n= number of outcomes)		Physical activity behaviour/PA cognitive (n= number of outcomes)		Weight-related (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
						benefits of exercise increased)		
Topp et al. (S78)	Deliens et al. (18)	Peer-education		**Intakes: n=5** (energy, fat, sugars and salt did not decrease; fiber did not increase)				
White et al. (S79)	Lua & Wan (23)	Peer-education		**Intakes: n=1** (overall healthy eating behaviour did not improve) **C-diet: n=2** (knowledge and attitudes of healthy eating did not improve)				
Yakusheva et al. (S80)	Plotnikoff et al. (26)	Effect of peers' (roommates) weight management behaviours on participants' weight				**PA behaviour: n=3** (frequency of exercising; use the gym, exercise outside decreased)		**WR: n=2** (body mass increased; proportion of participants trying to lose weight decrease)
Total number of outcomes			Total: 2 Dietary intakes: 1 C-diet: 1	Total: 9 Dietary intakes: 6 C-diet: 3	Total: 1 PA behaviour: - C-PA: 1	Total: 10 PA behaviour: 4 C-PA: 6	Total WR: -	Total WR: 2
Mixed/Other face-to-face interventions								
Boyle et al. (S81)	Masselli (2018) Plotnikoff et al. (26) Laska et al. (25)	In-class educational course plus peer education				**PA behaviour: n=6** (total PA; energy expenditure; VO2max; flexibility; chest press repetitions; leg press repetitions did not increase)	**WR: n=1** (WHR decreased only in women)	**WR: n=1** (body fat did not decrease)
Bray & Born (S82)	Masselli et al. (24)	Action-planning brochure and Physical Activity Guide tailored to first year students				**PA behaviour: n=1** (weekly minutes of MVPA decreased)		

Study	Reviews including the study	Brief description of intervention	**Dietary intakes/ Diet cognitive** (n= number of outcomes)		**Physical activity behaviour/PA cognitive** (n= number of outcomes)		**Weight-related** (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Brown et al. (S83)	Maselli et al. (24) Deliens et al. (18)	Interactive activities within student residence building		**Intakes: n=1** (FVI did not increase)	**PA behaviour: n=1** (MVPA increased) **C-PA: n=1** (action planning towards PA increased)	**C-PA: n=1** (outcome expectations towards PA did not increase)		
Chapman et al. (S84)	Deliens et al. (18)	Intention-based intervention by pre-intervention instructions	**Intakes: n=1** (FVI increased)					
Levy & Auld (S85)	Laska et al. (25) Lua & Wan (23)	Four sessions of cooking classes, and a supermarket tour	**C-diet: n=3** (cooking attitudes, knowledge and behaviour improved)					
Sallis et al. (S86)	Masselli et al. (24) Plotnikoff et al. (26) Laska et al. (25)	Class course plus peer-training			**PA behaviour: n=3** [total PA; strengthening activities; and flexibility activities increased (only for females)]	**PA behaviour: n=2** (VPA and MPA did not increase)		
Zhang & Cooke (S87)	Deliens et al. (18)	Motivation or/and volitional intervention including educational leaflets and action and coping sheets	**Intakes: n=2** (FVI increased; fat decreased)					
Total number of outcomes			Total: 6 Dietary intakes: 3 C-diet: 3	Total: 1 Dietary intakes: 1 C-diet: -	Total: 5 PA behaviour: 4 C-PA: 1	Total: 10 PA behaviour: 9 C-PA: 1	Total WR: 1	Total WR: 1
Overall number of outcomes of all interventions			**Total: 43** **Dietary intakes: 28** **C-diet: 15**	**Total: 40** **Dietary intakes: 37** **C-diet: 3**	**Total: 24** **PA behaviour: 22** **C-PA: 2**	**Total: 59** **PA behaviour: 47** **C-PA: 12**	**Total WR: 11**	**Total WR: 7**

Appendix II.D. E-interventions

Supplemental table 3. Brief description of e-interventions targeting dietary, physical activity and weight-related outcomes in university students, reviews including them, and number of improved/not improved outcomes appear in reviews[3]

Study	Reviews including the study	Brief description of intervention	**Dietary intakes/Diet cognitive** (n=number of outcomes)		**Physical activity behaviour/ PA cognitive** (n=number of outcomes)		**Weight-related** (n=number of outcomes)	
			Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Interventions delivered through the world wide web								
Brown et al. (S88)	Plotnikoff et al. (26)	Online vegetable preparation videos and vegetable testing	**Intakes: n=1** (intake of asparagus increased) **C-diet: n=2** (stage of readiness to change behaviour and self-efficacy for vegetable preparation increased)	**Intakes: n=4** (total vegetables, onions, potatoes, and salad greens did not increase)				
Cavallo et al. (S89)	Maselli et al. (24) Plotnikoff et al. (26)	Educational website with self-monitoring tools plus online social group (Facebook) and prompting email messages				**PA behaviour: n=4** (energy spent in total PA, moderate, heavy and light activities) **C-PA: n=1** (perceived social support towards exercise did not increase)		
Clifford et al. (S90)	Deliens et al. (18) Kelly et al. (22) Laska et al. (25)	Online cooking program (4 sessions x15-min)	**C-diet: n=4** (knowledge, motivation and self-efficacy for cooking increased; cooking barriers decreased)	**Intakes: n=1** (FVI did not increase) **C-diet: n=1** (cooking behaviour did not improve)				

[3]C-diet: Cognitive Dietary outcomes; C-PA: Cognitive Physical Activity outcomes; FVI: Fruit and Vegetable Intake; MET: Metabolic Task Equivalent; MPA: Moderate Physical Activity; NC: information Not Clear; PA: Physical Activity; VPA: Vigorous Physical Activity; WHR: Waist-to-Hip Ratio; WR: Weight-related outcomes

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Diet cognitive (n=number of outcomes)		Physical activity behaviour/ PA cognitive (n=number of outcomes)		Weight-related (n=number of outcomes)	
			Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Epton et al. (S91)	Maselli et al. (24)	Website containing a profile page, theory-based messages and a planner with menus to implement goals.				**PA behaviour: n=1** (MVPA did not increase) **C-PA: n= 7** (descriptive norm, injunctive norm, perceived control, self-efficacy, intention, plan, and attitude toward PA did not improve)		
Franko et al. (S92)	Maselli et al. (24) Deliens et al. (18) Kelly et al. (22) Lua & Wan (23)	Online educational program with text-based and audio information, interactive activities, feedback and goal setting	**Intakes: n=1** (FVI increased) **C-diet: n=2** (perceived social support and self-efficacy for FVI increased)	**Intakes: n=1** (fat intake did not decrease)	**C-PA: n=2** (perceived barriers towards PA decreased; perceived beliefs on PA benefits increased)	**PA behaviour: n=1** [MVPA (MET min/week) did not increase)		
Gow et al. (S93)	Plotnikoff et al. (26) Lua & Wan (23) Laska et al. (25)	Online educational program with behaviour checklists and tailored feedback plus email messages		**Intakes: n=3** (FVI and fibre intake did not increase; fat intake did not decrease)		**PA behaviour: n=4** (total PA, walking, MPA and VPA in MET-min did not increase)	**WR: n=1** (BMI decreased)	**WR: n=1** (body weight did not change)
Greene et al. (S94)	Maselli et al. (24) Deliens et al. (18)	Online educational program with activities, goal setting and feedback	**Intakes: n=1** (FVI increased)			**PA behaviour: n=1** [MVPA (MET min/week) decreased]		
Grim et al. (S95)	Plotnikoff et al. (26)	Online program including skill-building, assignments and activity log			**PA behaviour: n=1** (frequency of VPA increased) **C-PA: n=2** (self-regulation and outcome expectancy value toward PA increased)	**PA behaviour: n=1** (frequency of MPA did not increase) **C-PA: n=2** (friend social support and self-efficacy toward PA did not increase)		
Harvey-Berino et al. (S96)	Plotnikoff et al. (26)	Online weight management program with					**WR: n=1** (body weight reduced)	

Study	Reviews including the study	Brief description of intervention	**Dietary intakes/Diet cognitive** (n=number of outcomes)		**Physical activity behaviour/ PA cognitive** (n=number of outcomes)		**Weight-related** (n=number of outcomes)	
			Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
		behavioural skill-building plus online chats with facilitators, social groups, food logs, diet and exercise prescriptions						
Huang et al. (S97)	Plotnikoff et al. (26)	Website with stage-matched messages			**C-PA: n=1** (self-efficacy toward PA increased)	**PA behaviour: n=1** [total PA (MET-min) did not increase] **C-PA: n=3** (knowledge of fitness, benefits and barriers to activity did not improve)		
Kattelmann et al. (S98)	Maselli et al. (24) Deliens et al. (18)	Online educational lessons plus email messages	**Intakes: n= 2** (FVI increased; fat intake decreased)	**Intakes: n=2** (sugary beverages did not decrease; whole grains did not increase)		**PA behaviour: n=4** (MET min/week of total PA, walking, MPA and VPA did not increase) **C-PA: n=1** (stage of readiness to change did not increase)		
LaChausse (S99)	Deliens et al. (18) Plotnikoff et al. (26)	Online program including educational information, rating assessments, and tailored feedback	**Intakes: n=2** (Fruit and vegetable intake both increased) **C-diet: n=1** (self-efficacy for FVI increased)		**PA behaviour: n=1** (frequency of aerobic activity increased)	**C-PA: n=2** (attitude and self-efficacy towards exercise did not increase)		**WR: n=1** (BMI did not decrease)
Levitsky et al. (2 studies) (S100)	Laska et al. (25)	Email messages with tailored feedback					**WR: n=1** (body weight reduced)	

Study	**Reviews including the study**	**Brief description of intervention**	**Dietary intakes/Diet cognitive** (n=number of outcomes)		**Physical activity behaviour/ PA cognitive** (n=number of outcomes)		**Weight-related** (n=number of outcomes)	
			Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Magoc et al. (S101)	Maselli et al. (24) Plotnikoff et al. (26)	Online educational program with assignments, goal-setting, social support and activity logs.			**PA behaviour: n=2** (frequency of MPA and VPA increased)	**PA behaviour: n=2** [MPA and VPA (min/week) did not increase] **C-PA: n=5** (perceived self-efficacy, goals, plans, expectancies, family and friends social support did not increase)		
Morris & Merrill (S102)	Kelly et al. (22)	Online program to enter dietary intake and receive tailored feedback		**Intakes: n=1** (overall eating habits did not improve)				
Okazaki et al. (S103)	Maselli et al. (24)	Website with information, goal-setting, quizzes, exercises and tailored advice.				**PA behaviour: n=1** (energy spent on exercise increased only for those not engaged in regular PA at baseline) **C-PA: n=1** (stage of change score toward PA increased)		
Parrott et al. (S104)	Maselli et al. (24) Laska et al. (25)	Positive framed - email messages			**PA behaviour: n=1** (frequency of MVPA increased) **C-PA: n=5** (intention, affective attitude, instrumental attitude, subjective norm, and perceived behavioural control increased)			
Poddar et al. (S105)	Kelly et al. (22) Laska et al. (25) Lua & Wan (23)	Website with posted information, behaviour checklists, tailored feedback plus email	**C-diet: n=2** (self-regulation and self-efficacy for dairy intake increased)	**Intakes: n=1** (intake of dairy did not increase) **C-diet: n=2** (outcome				

Study	Reviews including the study	Brief description of intervention	**Dietary intakes/Diet cognitive** (n=number of outcomes)		**Physical activity behaviour/ PA cognitive** (n=number of outcomes)		**Weight-related** (n=number of outcomes)	
			Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
		messages		expectations and social support for dairy intake did not increase)				
Priebe & Spink (S106)	Maselli et al. (24)	Email messages with motivational information				**PA behaviour: n=1** (frequency of total PA did not increase)		
Quintiliani et al. (S107)	Maselli et al. (24)	Web-delivered messages with tailored planning and feedback.			**PA behaviour: n=1** [VPA (min/week) increased]	**PA behaviour: n=1** [MPA (min/week) did not increase] **C-PA: n=4** (no improvements in intention, self-efficacy, goal commitment and goal difficulty toward PA at follow-up)		
Skar et al. (S108)	Maselli et al. (24) Plotnikoff et al. (26)	Online questionnaire to create acting plans or/and coping plans for barriers plus online educational materials				**PA behaviour: n=1** (frequency of total PA did not increase) **C-PA: n=2** (perceived behavioural control did not increase; intention for PA decreased)		

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Diet cognitive (n=number of outcomes)		Physical activity behaviour/ PA cognitive (n=number of outcomes)		Weight-related (n=number of outcomes)	
			Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Wadsworth & Hallam (S109)	Maselli et al. (24) Plotnikoff et al. (26)	Educational website with cognitive variables, emails, e-counsellor, social support, discussion boards, and computer-mediated exercise materials				**PA behaviour: n=1** (frequency of MPA increased in 6 weeks but did not maintain in 6 months) **C-PA: n= 3** (perceived self-regulation, self-efficacy and outcome expectancy towards exercise did not improve at 6 months)		**WR: n=1** (body fat did not decrease)
Winzelberg et al. (S110)	Lua & Wan (23)	Online educational with group discussion, interactive activities and feedback					**WR: n=1** (body satisfaction rating improved)	
Total number of outcomes			Total: 18 Dietary intakes: 7 C-diet: 11	Total: 16 Dietary intakes: 13 C-diet: 3	Total: 16 PA behaviour: 6 C-PA: 10	Total: 55 PA behaviour: 24 C-PA: 31	Total WR: 4	Total WR: 3
Interventions using technology								
Brown et al. (S111)	Deliens et al. (18)	Mobile text messages	**Intakes: n=1** (fruit intake increased)	**Intakes: n=3** (whole grain, vegetables/ potatoes, milk/ yoghurt/cheese did not increase) **C-diet: n=2** (skipping breakfast and eating at restaurants did not improve)				
Jackson & Howton (S112)	Laska et al. (25)	Wearing a pedometer			NC			
LeCheminant et al. (S113)	Maselli et al. (24) Plotnikoff et al. (26)	Wearing a pedometer plus				**PA behaviour: n=6** (VO2max, treadmill		**WR: n=3** (body weight, WC

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Diet cognitive (n=number of outcomes)		Physical activity behaviour/ PA cognitive (n=number of outcomes)		Weight-related (n=number of outcomes)	
			Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
		activity log with goal-setting and email reminders				time and heart rate did not improve. Steps/day, frequency of MPA and VPA did not increase) **C-PA: n=1** (rating of perceived exertion did not improve)		and body fat did not decrease)
Ornes & Ransdell (S114)	Laska et al. (25)	Online program with goal-setting plus wearing pedometers			NC			
Rote et al. (S115)	Maselli et al. (24)	Wearing a pedometer, PA logs and goal-setting plus Facebook social group or emails with tailored feedback			**PA behaviour: n=1** (daily steps increased in both groups)			
Sriramatr et al. (S116)	Maselli et al. (24)	Wearing a pedometer, educational website with goal-setting, plus email messages with advice and feedback			**PA behaviour: n=2** (daily steps and frequency of LPA increased) **C-PA: n=3** (self-efficacy, outcome expectations and self-regulation toward PA increased)	**PA behaviour: n=2** (frequency of MPA and VPA did not increase)		
Tully & Cupples (S117)	Plotnikoff et al. (26)	Wearing a pedometer			**PA behaviour: n=1** (daily steps increased)	**PA behaviour: n=1** (VO2max did not improve)		**WR: n= 3** (body weight, BMI, WHR did not decrease)
Total number of outcomes			Total: 1 Dietary intakes: 1 C-diet: -	Total: 5 Dietary intakes: 3 C-diet: 2	Total: 7 PA behaviour: 4 C-PA: 3	Total: 10 PA behaviour: 9 C-PA: 1	Total WR: -	Total WR: 6
Overall number of outcomes of all interventions			**Total: 19** **Dietary intakes: 8** **C-diet: 11**	**Total: 21** **Dietary intakes: 16** **C-diet: 5**	**Total: 23** **PA behaviour: 10** **C-PA: 13**	**Total: 65** **PA behaviour: 33** **C-PA: 32**	**Total WR: 4**	**Total WR: 9**

Appendix II.E. Combined modes of interventions

Supplemental table 4. Brief description of combined modes of interventions targeting dietary and weight-related outcomes in university students, reviews including them, and number of improved/not improved outcomes appear in reviews[4]

Study	**Reviews including the study**	**Brief description of intervention**	**Dietary intakes/Diet cognitive**		**Weight-related outcomes** (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Cholewa & Irwin (S118)	Laska et al. (25)	''Buddy system'' (working in pairs) vs online logbook for goal-setting and tracking progress				**WR: n=1** (BMI did not decrease)
Evans & Mary (S119)	Plotnikoff et al. (26) Laska et al. (25)	Group-based education plus peer-education plus POP information, website, cafeteria tours, videos	**Intakes: n=2** (FVI increased; fat intake decreased)	**Intakes: n=1** (fruit juice consumption increased)		
Mailey et al. (S120)	Maselli et al. (24)	Accelerometer with tailored feedback, website, tailored feedback plus attendance of meeting with counsellors.		*The study targeted physical activity outcomes. Results were excluded from the table because the sample included only students with mental health disorders.*		
Musgrave & Thornbury (S121)	Plotnikoff et al. (26)	Caloric modification of regular menus in the canteen plus instruction and encouragement in weekly group meetings				NC
Richards et al. (S122)	Deliens et al. (18) Kelly et al. (22) Laska et al. (25)	Tailored newsletters, motivational interview, tailored email messages plus educational website	**Intakes: n=1** (FVI increased) **C-diet: n=1** (self-efficacy for FVI increased)	**C-diet: n=1** (perceived pros and cons for FVI did not improve)		

[4]C-diet: Cognitive Dietary outcomes; FVI: Fruit and Vegetable Intake; NC: information Not Clear; WR: Weight-related outcomes

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Diet cognitive		Weight-related outcomes (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Overall number of outcomes			**Total: 4** **Dietary Intakes: 3** **C-diet: 1**	**Total: 2** **Dietary intakes: 1** **C-diet: 1**		**WR: 1**

Appendix II.F. References of supplementary tables 1-4 (reported as SR in tables, where R is the citation number)

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Appendix III. The content (questions and answers) of the quiz-games of the e-programme

Activity and exercise

Questions	Answers	Correct answer
Exercising has many health benefits. Which of the following is NOT true about doing exercise?	It reduces the risk of chronic diseases	X
	It improves self-esteem	X
	It relieves stress	X
	It decreases metabolism	√
How much weekly aerobic activity should we achieve to get health benefits?	More than 150 minutes of moderate intensity	X
	Less than 150 minutes of moderate intensity	X
	75 minutes of vigorous intensity activity	X
	Both answers 1 & 3 are correct	√
Which of the following activities are considered moderate intensity?	Walking fast, skateboarding or playing double tennis	√
	Jogging, paying rugby or swimming fast	X
4. Which of the following activities are vigorous intensity?	Playing single tennis	√
	Hiking	X
	Walking fast	X
	Recreational cycling	X
5. Besides aerobic exercise, how often is it good to do exercise that strengthens your muscles?	Once per week	X
	At least twice per week	√
6. Which muscle groups should be targeted by exercise?	Mainly the upper body	X
	Mainly the lower body	X
	Lower and upper limbs, torso and muscles of the back	√
	Mainly the abdomen	X
7. Which of the following activities will speed up your metabolism?	Decrease fat mass	X
	Increasing muscle mass through exercise	√
	Increasing sitting time	X
	Drinking water	X
8. How many calories would a 70kg (154.32 lb) person burn, if walking fast for one hour	Approximately 300-400 kcal	√
	Approximately 500-600 kcal	X
9. The opposite of doing activity is sitting. Why is it important to reduce sitting time?	It can lead to overweight and obesity	X
	It is thought to slow metabolism	X
	It is related with early death	X
	All the above are correct	√

Questions	Answers	Correct answer
10. Finally, which of the following will NOT help you reduce your sitting time?	Taking the stairs instead of the lift	X
	Playing with the PC while eating	√
	Walking around while talking on the phone	X
	Getting off the bus earlier and walk the rest of the way	X

Alcohol

Questions	Answers	Correct answer
1. What is the maximum recommended intake of alcoholic drinks per day?	2 drinks for men and 1 drink for women	X
	3 drinks for men and 2 drinks for women	X
	1 drink for men and 1 drink for women	√
	2 drinks for men and 2 drinks for women	X
2. How many units of alcohol are recommended per day, maximum?	Less than 1 unit	X
	Less than 2 units	√
	Less than 3 units	X
	Less than 4 units	X
3. How many units are in our favourite drinks such as… in a pint of beer?	1.0 unit	X
	2.3 units	√
	3.0 units	X
4. Or… in a small shot of tequila?	1.0 unit	√
	2.0 units	X
	3.0 units	X
5. Or… in a glass (250 ml) of wine?	1.5 unit	X
	2.0 units	X
	3.0 units	√
6. How much time does the body need to digest this glass of wine?	2 hours	X
	3 hours	√
	4 hours	X
	5 hours	X
7. What is binge drinking?	Drink a lot of alcohol in short time or drink to get drunk	√
	Drink a slightly higher amount than the recommended one	X
8. Why should binge drinking be avoided?	It decreases self-control	X
	It increases the risk of accidents	X
	It can lead to misjudgement of risky situations	X
	All the above are correct	√
9. Why people should not overconsume alcohol?	It can lead to heart diseases	X
	It can damage the liver	X
	It can cause depression	X

Questions	Answers	Correct answer
	All of the above are correct	√
10. Choose a good tip for someone who wants to cut down their alcohol intake:	To consume always the same drink To pick up a specific day per week and drink only that day To go for a smaller size of the drink To mix up the drink with a soft drink	X X √ X

Fast-food

Questions	Answers	Correct answer
Let's admit it: Fast-food is tasty! But what exactly is fast-food?	Processed food high in calories, fat, salt or sugars Processed food high in allergens and toxins	√ X
Which of the following foods belong to processed foods?	Microwave meals or ready meals Genetically modified foods	√ X
How often is it recommended to eat junk food?	Once a month Once a week Twice a week Only occasionally	X X X √
Why is the recommended intake of junk-food so low?	It can lead to abdominal obesity It can lead to prediabetes and metabolic syndrome It can be addictive All of the above reasons are correct	X X X √
Which body-shape has a higher risk to developing metabolic syndrome?	The apple-shaped The pear-shaped	√ X
Which of the following are healthier options when eating fast-food?	Choose the cheapest meal Avoid extras like cheese, bacon and mayo Prefer wraps instead of burgers Prefer ketchup instead of mayo	X √ X X
What would you do to reduce calories from fat contained in fast-food?	Choose a diet soft-drink instead of a sugary drink Avoid fried sides such as chips and fries Both of the above answers are correct	X √ X
How many calories does a double cheeseburger contain on average?	250 kcal 350 kcal 450 kcal 550 kcal	X X √ X
How many calories does a	260 kcal	X

Questions	Answers	Correct answer
large packet of French fries contain on average?	360 kcal	X
	480 kcal	√
	710 kcal	X
How many calories does a chicken wrap contain on average?	277 kcal	X
	377 kcal	X
	477 kcal	√
	577 kcal	X

Fat

Questions	Answers	Correct answer
Is fat that bad? Let's find out! Which of the following is NOT true about fat?	It helps the body to absorb vitamins A, D and E	X
	It is not necessary for normal body function	√
	It gives more calories per gram than carbs or proteins	X
	It is a source of essential fatty acids	X
Some types of fat are good and some are bad! Which of the following are considered bad fats?	Saturated and polyunsaturated fat	X
	Trans and monounsaturated fat	X
	Saturated and trans fat	√
	Polyunsaturated and monounsaturated	X
Which of the following are rich in saturated fat?	Butter and sausages	√
	Olive oil and salmon	X
	Rapeseed oil and walnuts	X
	Sunflower oil and avocado	X
Which of the following are rich in *trans* fat?	Fish and chicken	X
	Biscuits and pastries	√
	Eggs and milk	X
	Cereals and yogurt	X
Which of the following is rich in monounsaturated fat?	Olive oil	√
	Coconut oil	X
	Fish oil	X
	Sunflower oil	X
Which of the following is rich in polyunsaturated fat?	Rapeseed oil	√
	Olive oil	X
	Coconut oil	X
	All of the above are good sources	X
What is the role of essential (omega-3 and omega-6) fatty acids?	They are components of cell membranes	X
	They participate in many regulatory pathways	X
	They have anti-inflammatory effects	X
	All of the above responses are correct	√
Which of the following are good sources of omega-3 and	Oily fish such as mackerel	√
	Coconuts and coconut oil	X

Questions	Answers	Correct answer
omega-6 fatty acids?		
Why is it important to prefer unsaturated fat compared to saturated fat?	They protect heart by maintaining good cholesterol levels	X
	They protect heart by reducing levels of bad cholesterol	X
	They provide the body with the essential fatty acids	X
	All the above responses are correct	√
What advice would you give to someone who wants to reduce their saturated fat intake?	Boil the sausages instead of baking it	X
	Use semi-skimmed milk instead of full-fat milk	√
	Use margarine instead of butter while cooking	X
	Add a salad-dressing instead of olive oil to salads	X

Food labels

Questions	Answers	Correct answer
Food labels help you select healthy foods. What is usually shown on food labels?	Energy content	X
	Energy, sugars and salt	X
	Energy, fat and salt	X
	Energy, fat, saturated fat, sugars and salt	√
Food labels often use traffic colours. What does an amber colour indicate?	The nutrient is present in high amounts	X
	The nutrient is present in moderate amounts	√
	The nutrient is present in low amounts	X
	The nutrient is safe to be consumed	X
What does a red colour indicate on a food label?	The nutrient is present in high amounts	√
	The nutrient is present in moderate amounts	X
	The nutrient is present in low amounts	X
	The nutrient is safe to be consumed	X
And what does a green colur indicate on a food label?	The nutrient is present in high amounts	X
	The nutrient is present in moderate amounts	X
	The nutrient is present in low amounts	√
	The nutrient is safe to be consumed	X
Now that you've learnt the traffic colour coding, which product would be the best option?	The one with an equal number of red and green signs	X
	The one with the least reds, no matter the other colours	X
	The one with the most greens, no matter the other colours	√
	The one having only amber signs	X
These are food labels from two different cereal products.	Product 1 (image)	X
	Product 2 (image)	√

Questions	Answers	Correct answer
Which is the healthiest option?		
When looking at the nutritional value of two products, comparisons should be done:	Per portion size	X
	Per 100 grams	X
	Per portion, if they have the same portion, otherwise per 100g	√
	Comparisons cannot be made as they are different products	X
These are tables of nutritional information of two sugary products. Which one is less healthy?	Product 1 (image)	X
	Product 2 (image)	√
What does the order of t ingredient list indicate?	The first ingredients are the allergens	X
	The first ingredients are present in higher amounts	√
	The first ingredients are the preservatives additives	X
	The order of ingredients is random	X
From the image, can you tell which the main ingredient in this margarine is apart from water?	A mix of vegetable oils including olive oil	X
	A mix of vegetables oils except from olive oil	√
	Rapeseed, palm and olive oil	X
	Rapeseed, sunflower and olive oil	X

Fruit & Vegetables

Questions	Answers	Correct answer
Fruit and vegetables (F&V) are a good source of:	Carbohydrates and fibre	X
	Carbohydrates and protein	X
	Carbohydrates and water	X
	Carbohydrates, fibre and water	√
How many portions of F&V should we eat daily?	Two	X
	Three	X
	Five	X
	At least five	√
Five A DAY it is! But what counts as one portion of fruit?	One medium size fruit or two small fruits	√
	Half of a large fruit or four small fruits	X
	Two small fruits or a large fruit	X
Which of the following would count as one portion of vegetables?	80g of raw vegetables	X
	Three heaped tablespoons of cooked vegetables	X
	Three heaped tablespoons of baked beans	X
	All of the above count as one portion of vegetables	√
Besides fruit and veggies, what else counts towards your 5 A DAY?	One medium-sized potatoe	X
	150 ml of fresh fruit or vegetable juice	√
If you drink 2 glasses of fruit juice, how many portions of your 5 A DAY would that count for?	One	√
	Two	X
	Three	X
	None	X
What are the health benefits of eating 5 A DAY?	It reduces the risk of heart diseases and some cancers	√
	It reduces the risk of type 1 diabetes	X
	It exacerbates constipation	X
	All of the above are correct	X
Eating a variety of F&V is recommended. Choose the best option:	Lettuce, green peppers and broccoli	X
	Red peppers, tomatoes and carrots	X
	Broccoli, carrots and tomatoes	√
	Lettuce, cucumber and cabbage	X
Supposing that you try to increase your 5 A DAY intake. Choose a good option:	Add a banana to your breakfast cereals	X
	Drink a glass (250ml) of orange juice with breakfast	X
	Add sultanas to your breakfast cereals	X
	All the above are good options	√
If you plan to eat an omelette for dinner, the best option would be:	To add pickles and tomatoes	X
	To add peppers and mushrooms	√

Meals & snacks

Questions	Answers	Correct answer
Are you familiar with the UK dietary guidelines? They appear in the *Eatwell Guide*, which shows:	How much of each food group to eat to achieve a healthy diet	√
	How food should be placed on the plate	X
According to the *Eatwell Guide*, 1/3 of every meal should contain:	Fruits and vegetables	X
	High-protein foods such as dairies and meat	X
	Starchy foods such as rice, bread and pasta	√
	Fatty foods such as butter and olive oil	X
Starchy foods give you energy, but some are healthier. Which ones?	The processed ones such as white bread and rice	X
	The unprocessed ones such as wholegrain rice and oats	√
Which of the following foods are rich in protein?	Meat, fish and eggs	X
	Milk and dairy foods	X
	Beans and pulses	X
	All of the above are high-protein foods	√
Fish is rich in protein, healthy fats and vitamins. This is why it is advised to eat:	At least one portion per day	X
	At least one portion per week	X
	At least two portions per month, including one of oily fish	X
	At least two portions per week, including one of oily fish	√
We all love sugary treats! But how frequently and how much should be eaten?	Never	X
	Occasionally and in small amounts	√
	Occasionally but in large amounts	X
	As often as we want if our body weight is healthy	X
You may skip breakfast but eating breakfast daily is important. *Why?*	It fills up the energy stores used up at night	X
	It gives energy for the morning activities	X
	It helps maintaining a healthy body weight	X
	All of the above reasons are correct	√
Can you think which of the following would be the best option for a healthy breakfast?	Low-fat yogurt with oats and fresh fruit	√
	White bread with cream cheese and fruit juice	X
	Omelette with sausages and beans and low-fat milk	X
	Whole-grain bread with honey and full-fat milk	X
How frequently should snacks be consumed daily?	As frequent as we want	X
	When we are hungry and between meals	√
	Between breakfast and lunch	X
	Between lunch and dinner	X

Questions	Answers	Correct answer
Before we finish, which of the following will NOT be a good option for a snack?	Veggie sticks with yogurt Low-fat frozen yogurt with berries Smoothie with oats, banana and low-fat yogurt Oatmeal pancakes with maple syrup	X X √ X

Meat

Questions	Answers	Correct answer
Meat is a good source of:	Protein, iron and vitamin C Protein, vitamin C and cobalamin (B12) Protein, iron and cobalamin (B12)	X X √
Meat includes white, red and processed meat. What is processed meat?	Meat soaked in marinade before cooking Meat preserved by smoking, curing or salting	X √
Which of the following are examples of processed meat?	Beef, pork and lamb Sausage, bacon and ham	X √
Processed meat contains high amounts of:	Polyunsaturated fat and salt Saturated fat and salt Trans fat and saturated fat Monounsaturated fat and trans fat	X √ X X
It is advised to eat only 70g of red and processed meat daily, *why?*	It increases the risk of developing some cancers It increases the risk of a heart diseases It can raise blood cholesterol levels All the above are correct	X X X √
How much weight of a thin cut slice of beef equals to 70g of red processed meat?	10g 30g 50g 80g	X √ X X
How much red meat has an English breakfast with two sausages and two rashers of bacon?	200g 150g 130g 90g	X X √ X
For dinner you plan to eat 70g of chicken. How much raw meat should you buy?	50g 70g 100g 150g	X X √ X
If you fancy eating meat, how could you reduce some of the fat content?	By eating it with roast potatoes instead of fried potatoes By cutting it in small pieces before eating it By cooking with olive oil instead of butter or	X X X

Questions	Answers	Correct answer
	lard	
	By removing the skin and any visible fat	√
But if you are not a meat-lover, which meal would be a good protein alternative?	A salad with mixed beans and wild rice	√
	A potato salad with beetroot and peppers	X

Salt

Questions	Answers	Correct answer
Salt is made up of sodium and chloride. What is its main body function?	It helps control fluid balance and muscle function	√
	It helps liver to waste toxins	X
	It helps uptake of blood glucose into muscles	X
	All the above responses are correct	X
How much salt should we eat daily?	4 grams	X
	5 grams	√
	6 grams	X
	7 grams	X
Why is it important to avoid a high salt intake?	It's a major risk factor for hypertension and heart diseases	√
	It's a major risk factor for obesity and diabetes	X
	It's a major risk factor for metabolic syndrome and gout	X
	All the above reasons are correct	X
Food is considered as high in salt when it contains more than…	1.0 gram of salt per 100g	X
	1.5 grams of salt per 100g	√
	2.0 gramps of salt per 100g	X
	2.5 grams of salt per 100g	X
Food is considered low in salt when it contains less than…	100 mg of salt per 100g	X
	200 mg of salt per 100g	X
	300 mg of salt per 100g	√
	400 mg of salt per 100g	X
Which one of the following is more likely to be low in salt?	Canned soup	X
	Soya sauce	X
	Cottage cheese	X
	Eggs	√
Can you identify the possible *secret sources* of salt?	Breakfast cereals and biscuits	X
	Breakfast cereals and sandwich bread	X
	Biscuits and breakfast cereals but not sandwich bread	X
	Biscuits, breakfast cereals and sandwich bread	√

Questions	Answers	Correct answer
Identify the snack with the lowest amount of salt:	Cheese cubes	X
	Dried peas	√
	Instant hot chocolate	X
	Bagel	X
One way to add flavour but reduce salt in food is by using:	Herbs and spices	√
	Soya sauce	X
	Vegetable stock tubes	X
	Salad dressings	X
Finally, what advice would you give to someone that wants to reduce their salt intake?	To add salt only while cooking but not after	X
	To cook from scratch and avoid ready-to-eat meals	X
	Both answers are correct	√

Sugars and sugary drinks

Questions	Answers	Correct answer
You might think table sugar is the only sugar, but it's not! What else counts as sugars?	Fructose, corn syrup and honey	√
	Aspartame, saccharin and sorbitol	X
And why are they called *added sugars?*	To separate them from those naturally found in foods	√
	Because they can be easily added to foods	X
Which of the following have added sugars?	Natural yogurt, canned soup	X
	Melon, cereal bars	X
	Ketchup, fruit yogurt	√
	Mustard, breakfast cereals	X
Eating too many added sugars can lead to:	Tooth decay and fat accumulation	X
	Excess weight	X
	Atheromatic plaques	X
	All of the above are correct	√
Sugars have a high Glycaemic Index (GI). Why should high GI foods be avoided?	They cause rapid changes in blood sugar levels	√
	They cause homogenous increases in blood sugar levels	X
Why are rapid increases in blood glucose levels harmful for health?	It may lead to exhaustion and fatigue	X
	It may lead to over-consumption of food	√
	None of the above are correct	X
	All of the above are correct	X
How many sugars should we eat per day?	Approximately 20g or 4 teaspoons	X
	Approximately 30g or 6 teaspoons	√
How many teaspoons of sugar	5	X

Questions	Answers	Correct answer
does a can of cola contain?	6	X
	7	√
	8	X
Diet soft drinks are not a good option either! Can you think of the reason?	They could harm your teeth	X
	They can increase the risk of obesity	X
	All of the above are correct	√
	None of the above are correct	X
Water is the best drink to quench your thirst! What would be satisfied daily intake?	At least 5 glasses	X
	Exactly 6-8 glasses	X
	6-8 glasses if you don't drink other fluids	√
	More than 8 glasses	X

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