Rationale and design of an online educational programme using a game-based learning platform to improve nutrition and physical activity outcomes among university students in the UK.

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ABSTRACT

Objective: To assess the impact of online quiz-games on nutrition knowledge and related outcomes among university students in the UK.

Design: Randomized controlled trial with pre and post intervention comparisons.

Setting: Two higher education settings in London, UK

Participants: Current undergraduate and postgraduate students of two universities (n=90) aged 18-34 years will be randomly allocated to an intervention (n=45) or a control group (n=45).

Intervention: The intervention group will receive access to a website and online quiz-games including educational information about healthy eating and physical activity. The control group will receive no information. Duration of the intervention will be 10 weeks.

Outcome Measure(s): Primary outcome is nutrition knowledge. Secondary outcomes include diet and activity behaviours. Nutrition and activity knowledge and behaviour will be assessed using questionnaires. Weekly steps will be counted using pedometers. Anthropometry and assessment of metabolic risk factors will take place.

Analysis: Quantitative analysis will investigate changes in knowledge regarding healthy eating and physical activity between the groups of the studying population. Factors affecting knowledge will be explored. Associations between changes in knowledge and dietary and physical activity behaviour will be assessed by correlations.

Key words: *health education, internet, nutrition, exercise, university*

INTRODUCTION

The years that follow graduation from high school to study at university are often characterized by lifestyle changes such as less engagement in sports and decreased intake of fruits, vegetables and whole grain products.[1] A cross-sectional survey in the US reported that one out of three students consumed processed meat, sweets, fried potatoes and fast-food at least once or twice per week.[2] A similar study across seven UK universities found that only 15% of students reached the recommended intake of fruit and vegetables (≥5 servings/day) and 70% were eating sweets more than once per week, although the same proportion of students regarded healthy eating as "very important" for themselves.[3] The same study reported that only 13% of students reached the recommended levels of moderate activity with a significantly higher proportion of male students engaging in vigorous activity compared to their female counterparts.[3] Body composition changes also occur while at university and a recent meta-analysis of 49 prospective studies found an increase in students' body mass and body fat by 1.6 kg and 1.2% respectively, with weight increments distributing throughout studying years.[4] Additionally, university students seem to misunderstand nutrition facts, in particular with regards to diet-disease relationships[5] and healthy food choices[6] while many tend to consider a food item as healthy based on its manufacturing methods and additives rather than on its impact on health and body requirements.[7] Evidence suggests that an empowerment in nutrition knowledge and awareness of healthy eating facts could positively affect dietary behaviour.[8,9]

A plethora of interventions have been implemented to improve dietary and physical activity outcomes and prevent weight gain among university students, using different approaches.[10] Examples include an increase in fruit and vegetable intake after implementing face-to-face interactive workshops,[11] decreases in purchases of sugary drinks with the use of nutrition labelling on vending machines,[12] and improvements in nutrition knowledge[13] and exercise outcomes[14] after administering online educational programmes.

The use of technology and internet as a means to increase health awareness within universities is constantly increasing.[15] Gamification, i.e. the use of game elements, such as videos, challenge, skill, goals, award, feedback and social interaction, built upon behaviour change theories, is an additional modern learning approach attracted by many young people.[16] Game-learning seems to increase students' engagement and preserve knowledge for a longer period compared to traditional paper-based educational methods while it increases the appeal of learning process and the chances of positive learning outcomes.[17] It also provides instant feedback which motivates students while elaborates educators on students' misconceptions.[18] Online quizzes is another tool that has been used effectively in healthcare pedagogy to reinforce knowledge as possible facilitators include engagement, healthy competition and instant feedback on current knowledge.[19]

The current study will use online quizzes with game elements and a website as a source of information to increase knowledge on healthy eating and physical activity among university students. It will further explore factors affecting knowledge as well as the relationship between changes in the level of knowledge and diet and physical activity behaviour.

Based on the above rationale, the specific objectives for this research project will be to:

1. Assess the baseline level of nutrition knowledge, dietary habits, physical activity and metabolic risk indicators (BMI, waist to hip ratio, body fat, fat-free mass, blood pressure, and fasting blood glucose) in a sample of UK university students.

2. Examine the impact of an online educational intervention on the level of nutrition knowledge of the students.

3. Explore whether an increase in knowledge is related to improvements in dietary and physical activity habits and prevention of weight gain.

METHODS

Study design

A randomised controlled trial with two data collection points: one at baseline (T_0) and one after 10 weeks (T_{10}) from the initial measurements will be conducted. The trial will include two parallel groups, the intervention and the control group. Those in the intervention group will receive an online educational programme. The control group will receive no intervention. Randomization will take place using a software programme[20] and participants will be equally allocated to the two groups.

Participants

The participants will be students in one of the two UK higher education settings: 1) Kingston University, London, and 2) St George's, University of London. The University of St George's offers medical and paramedical courses, such as Medicine, Midwifery and Nursing while Kingston University offers a variety of courses such as Business, Law, Arts, Design, Mathematics, Engineering, Geology, Computing and Social Sciences. Eligible students will be those currently enrolled in undergraduate or postgraduate courses in one of two Universities and aged 18 to 34 years. Those who suffer from a long-term disease or follow a specific diet (e.g. diabetics) as well as pregnant and lactating women will be excluded from the study due to special nutritional requirements. Prior to engagement in the study, students will be further screened for their ability to perform a safe level of exercise using the PAR-Q questionnaire[21] or whether being at risk of eating disorders using the SCOFF questionnaire.[22] Those at risk will be excluded from the study and advised to refer to their general practitioner for further consultation.

Ethical approval and financial compensation

The study received approval by the Faculty Research Ethics Committee of Kingston University, London and St George's, University of London. The data will be handled according to the Declaration of Helsinki (2013). A £10 Amazon voucher award will be given to those students who complete both parts of the study.

Development of the Intervention

Website

A website will be developed to include evidence-based information relevant to healthy nutrition and physical activity. This information will be summarized in twelve health topics with the following subject headings: 1) Activity & Exercise, 2) Alcohol, 3) Body weight, 4) Fast-food, 5) Fat, 6) Food Labels, 7) Fruits & Vegetables, 8) Meals & snacks, 9) Meat, 10) Eating on a Budget, 11) Salt, and 12) Sugars and Sugary drinks. Each topic will include information about the relationship of nutrition or exercise with health and disease, useful definitions and often confused terms, tips and advice to improve eating and exercise behaviour as well as external links for further information. A brief summary of the website content is presented in Table 1.

Online quiz-games

Quiz-games will be developed to stimulate students, boost their knowledge and increase their engagement in the educational programme. Quiz-games will be developed using Kahoot! - a game-based learning platform using sociocultural, motivation and behaviourism theory constructs as well as gamification components.[23] The platform allows the educator to develop quizzes using the following game elements: visual aids, time, feedback, concentration, reward and social interaction. The answers from the games will further contribute to identifying additional gaps in students' knowledge. Overall, ten quiz-games will be created, one for each

of the above topics (excluding Body Weight and Eating on a Budget) as shown in Figure 1. Each game will consist of ten short questions and each question will have multiple choice answers (between two to four potential answers) with only one correct response. The quizzes will include educational material such as videos and gradually revealed pictures to provide further insight or hints to the addressed questions as well as entertainment features (e.g. music, animations). Time-restrictions will be applied to each question (30 seconds) and correct answers will lead to point collection while quicker responses of correct answers will lead to higher scores. At the end of each game, feedback regarding the total score and number of correct answers will individually appear on the screen. The platform encourages users to repeat the quiz in order to improve their high scores. Students will be advised to play as many times as they wish and use the website as a reference tool to look for the correct answers. Any electronic device will be able to host the quiz-games and students will have the opportunity to interact and see each other's scores if they are participating at the same game (invited by the same host). HTML iframes will be used to pinch the quiz-games to the website for easy access and customised usernames and passwords will be provided to students to access and play the games.

E-mails

E-mails will be sent twice per month to participants to provide feedback on their performance, ask whether they face any difficulties with the programme and prompt them to continue playing and improve their scores.

Adherence

Adherence to the intervention will be estimated based on the number of different games played and frequency of playing each game. High adherence will be considered if playing five or more

different games or more than five games in total (e.g. by playing the same game more than once), moderate adherence if playing three or four different games or more than four games in total and low adherence if playing one to three different games or one to four games in total.

Pre-and post-intervention measurements and outcomes of interest

Nutrition knowledge

Nutrition knowledge will be assessed using the General Nutrition Knowledge Questionnaire (GNKQ),[6] which is based on the most recent UK dietary guidelines and updated evidence-based nutritional facts.[24] The GNKQ includes four different sections of nutritional knowledge regarding dietary recommendations (18 items), food groups (36 items), health food choices (13 items) and diet-disease relationships (21 items). It has a reliability of more than 0.7 for all sections. Each correct answer gets a point (otherwise null) and the score range is 0-88. Results will be expressed as percentages of correct answers. Nutrition-related knowledge, and knowledge of physical activity, will be also assessed through the results of the quiz-games by estimating the total number of correct answers in each game, expressed as percentage, and the difference in scores when participants play a game multiple times.

Diet

Dietary habits will be assessed using a semi-quantitative Food Frequency Questionnaire (FFQ). The questionnaire will be based on the FFQ developed by Leppälä et al.,[25] which provides an Index of Diet Quality (IDQ). The IDQ reflects dietary intake of healthier foods and adherence to dietary recommendations. 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 meals consumed. Adjustments were made to include examples of local foods and the clarity and feasibility of the FFQ was tested among students

in a pilot study. Dietary intakes will be compared against the current UK dietary guidelines.[24] The IDQ scores will be calculated (0-15 points), with scores less than 9 indicating a poor diet quality and scores equal or more than 10 indicating a high diet quality as suggested by the authors of the questionnaire.

Physical activity

Physical activity will be assessed using the International Physical Activity Questionnaire (IPAQ-short version),[26] which includes questions about the frequency (days per week) and duration (min per day) of different activities (vigorous, moderate, walking) as well as daily sitting time (hours/day). Data will be presented as Metabolic Equivalent of Task (MET) per minute per week. Also, belt-clip pedometers (Tanita PD-637) will be used to count the number of weekly steps. Pedometers will be given for one week to record steps both in weekdays and weekends and will be cross-validated with the weekly walking activity assessed by the IPAQ. The recommended amount of steps to achieve health benefits is 10,000 per day.[27]

Demographic and socioeconomic data

Factors that affect nutrition and physical activity outcomes such as age, gender, ethnic group, field of study, residence status, perceived health rate, current dieting practices, smoking status and acquired nutrition qualifications, will be collected at baseline.[28]

Body composition

Body composition assessment will be undertaken by a highly trained researcher. Body mass will be measured to the nearest 0.1 kg using an electronic scale (Seca) and stature to the nearest 0.1 cm using a transportable stadiometer (Seca, Chino, CA). Body Mass Index (BMI) (kg/m^2) will be calculated based on mass (kg) and stature (m) and participants will be classified

according to their BMI percentiles as underweight (<18.5), healthy weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) or obese (≥30.0 kg/m^2).[29]

Body fat (%) and fat-free mass (kg) will be calculated by bioelectrical impedance using a segmental body composition analyser (TANITA BC-418). 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. For the ages of 20-39 years, a normal body fat will range between 21% and 33% for females and 8% to 20% for males. Participants will be advised to arrive fasting in the morning (fasting period >8 hours), urinate before the measurement and avoid intense exercise and alcohol intake the previous day.

Waist circumference (WC) and hip circumference (HC) will be measured to the nearest 0.1 cm using a standard flexible measuring tape (Seca). Waist circumference will be measured at the midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the mid-axillary line and HC at the largest circumference of the buttocks.[25] Waist to hip ratio (WHR) will be calculated based on the above measurements. A WC >94 cm for men and >80 cm for women and a WHR ≥0.90 cm for men and ≥0.85 for women indicate increased metabolic risk.[30]

Blood pressure and fasting blood glucose

Systolic and diastolic blood pressure (mmHg) will be measured using an electronic sphygmomanometer (Omron M4). Blood pressure will be measured twice, 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. The average of two readings for systolic and diastolic blood pressure will be considered as the final values. A blood pressure <135/85 mmHg and more than 90/60 mmHg is regarded as optimal while above 140/90 mmHg as high.[31]

Blood glucose (mmol/l) will be measured using a portable handheld blood glucose analyser (Accu-Chek Aviva) from capillary blood by fingerpick technique. Participants will be asked to come in the morning fasted and blood glucose will be compared against normative values (4.0 to 6.0 mmol/L).[32]

Participants' timeline including assessment outcomes and instruments is presented in table 2.

Sample size

The sample size calculation was based on the primary outcome, nutrition knowledge. Construct validity of the questionnaire was tested by comparing the mean scores in students studying Dietetics (n=96) vs English (n=89).[19] The total mean score was 79.3 (Standard Error: 0.51) for Dietetics students and 67.7 (Standard Error: 0.97) for English students. 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 these data, the standard deviations would be approximately 5 for the Dietetics students and 9 for the English students. Since there are not established thresholds to indicate a minimum clinically important difference for knowledge, we assumed that an 8%-9% (7.0-8.0 points) increase on the initial score would significantly improve diet quality, as suggested by other evidence.[8] Students from both Healthcare and non-Healthcare Faculties will be invited to participate in this study. Thus, a standard deviation between 7 and 9 is 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 will satisfy the above criteria. Considering a 30% drop out rate, the overall sample size needed for this study will be 90 participants.

Statistical analyses of outcomes

Descriptive statistics will be used to describe and calculate all data (extracted from measurements and questionnaires) and each participant's change from baseline to post

intervention (after 10 weeks). Differences on nutritional knowledge, diet and physical activity within and between the two groups over time will be assessed using intention to treat analysis. A further subgroup analysis between healthcare and non-healthcare students will take place. Hypotheses testing will be used to investigate whether these differences are statistically significant for the outcomes on a P=0.05 significance level. The student's t-test will be used for normally distributed data to assess the statistical significance of differences between mean values. The Mann-Whitney-U test will be used to assess the statistical significance of non-parametric data. Adjustments for multiple testing across the outcomes, such as Bonferroni Adjustment, will be applied depending on the characteristics of the data. If there is evidence of an imbalance between the control and intervention groups that might cause confounding, regression analysis will be used to adjust for it. Associations between the levels of change in nutrition and physical activity knowledge and changes in diet and physical activity will be examined by correlations (Pearson's correlation for parametric data and Spearman's correlation for non-parametric data).

DISCUSSION

Similar studies using online tools and technology have been implemented among university students to improve lifestyle outcomes. Examples include the use of images through text-messaging,[33] online cooking videos[34] and web-based educational courses[13] to effectively change outcomes such as knowledge of dietary guidelines,[33] improvement of current eating habits as well as attitudes towards exercise.[13] Gamification has also been used to increase fruit and vegetable intakes among schoolchildren[35] and physical activity among university students[36] and we expect that the results of this study will significantly contribute to the limited evidence in this field.

Regarding study design, a randomized controlled trial will be used to investigate for potential relationships between the online educational programme and levels of knowledge. Compared to a quasi-experimental design, random allocation reduces the possibility of confounding factors that might affect any differences found between the two groups. Due to ethical concerns, participants will be aware of the existence of the two groups while the nature of the intervention (educational) constitutes the blinding of outcomes infeasible. Intention to treat analysis will maintain the advantages of random allocation, as subjects that will drop out or will not adhere to the intervention will be included in the analysis. The sample size of the study has sufficient power to detect significant differences between the two groups. Recruitment will occur throughout one academic year to consider seasonal factors. Although one of the two Universities offers only healthcare courses, a great effort will be put to equally recruit participants from all disciplines and no further selection bias will be applied to allow generalizability of results. Evidence suggests that students from healthcare courses, such as nurses and midwives, have a high prevalence of overweight (~50%) and despite their role to promote health, they find it difficult to follow a healthy lifestyle.[37] Medical students also seem to have inadequate levels of nutrition knowledge.[38] The current study will contribute in this area by exploring differences in knowledge among healthcare and non-healthcare students and the potential impact of knowledge on actual dietary and exercise behaviours.

Outcome measures will be assessed using valid tools and widely used methods allowing for comparison of results with similar studies. Self-reported data on anthropometry will be avoided to increase accuracy and the researcher will be present while students complete the questionnaires to provide assistance and ensure that they will not search online for the correct answers. Duration of the intervention will be ten weeks, which provides enough time to engage in the educational programme without taking much of the leisure time of students, but a follow-up assessment will not take place to estimate the long-term effectiveness of the intervention.

Students' results of the quiz-games and estimation of adherence to the programme will help to explain potential changes observed among the variables while an evaluation inquiring students' perceptions about the programme will take place at the end of the study to inform future research.

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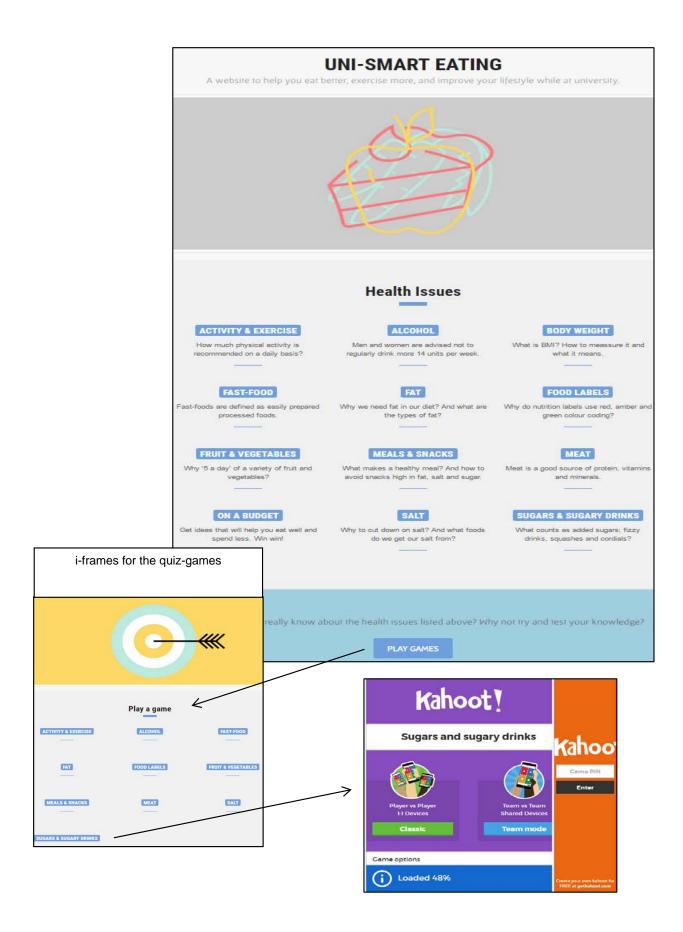
Figure 1. The educational website with the attached i-frames for the quiz-games

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

Health topics	Educational 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.
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 and glycaemic index.
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)	More details on the Eatwell Guide.

	Breakfast (importance for health, ideas, etc) Snacks (ideas, etc).	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 meat.	More information on meat (fat content, cooking methods, storing and freezing meat safely, meat alternatives, etc).
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.
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 (definition, food with a high, moderate and low GI). Top sources of added sugars in our diet. More tips to reduce sugars from meals.

Table 2. Participants' timeline including assessment outcomes and instruments

Outcomes	Instrument	Baseline (T_0)	Post-test (T_{10})
Primary endpoint			
Nutrition knowledge	General Nutrition Knowledge Questionnaire (GNKQ)	X	X
Secondary endpoints			
Dietary habits, diet quality	Diet Quality Index questionnaire	X	X
Physical activity	International Physical Activity Questionnaire (IPAQ) short / pedometers	X	X
BMI	Body weight: digital weight scale (Seca) Height: stadiometer (Seca, Chino, CA)	X	X
Other outcomes			
Waist circumference, hip circumference	Flexible measuring tape (Seca)	X	X
Body fat (%)	Bioelectrical impedance analysis (segmental body composition analyser TANITA BC-418).	X	X
Fat-free mass (kg)	Bioelectrical impedance analysis (segmental body composition analyser TANITA BC-418).	X	X
Systolic blood pressure (mmHg)	Electronic sphygmomanometer	X	X
Diastolic blood pressure (mmHg)	Electronic sphygmomanometer	X	X
Fasting blood glucose (mmol/l)	Capillary blood by fingerpicking using handheld blood glucose meter (Accu-Chek Aviva)	X	X
Socio-demographic factors			
Age, gender, origin, field of study, residence status, perceived health rate, dieting, smoking, nutrition qualifications	Questionnaire	X	
Screening			
Readiness for physical activity	Physical Activity Readiness Questionnaire (PAR-Q)	X	
Eating disorders	SCOFF questionnaire	X	