Original Article

# Role of behavioural feedback in nutrition education for enhancing nutrition knowledge and improving nutritional behaviour among adolescents

Louisa Ming Yan Chung R.Nutr, DHSc, MBA, BSc[1], Shirley Siu Ming Fong PT, PhD[2]

[1]*Department of Health and Physical Education, The Education University of Hong Kong, Hong Kong*
[2]*School of Public Health, The University of Hong Kong, Hong Kong*

**Background and Objectives:** The integration of nutrition knowledge into nutritional behaviour can help children to develop a healthy lifestyle that may be carried forward into adulthood. E-learning enables students to take ownership of recording their dietary intake and modify their diets by making their own decisions regarding food choices and portion sizes through reflective feedback. This study investigated the role of behavioural feedback in nutrition education in modifying students' nutrition knowledge and behaviour. **Methods and Study Design:** Ninety-five secondary students studying from Secondary 1 to Secondary 3 were recruited from five schools. Moreover, 50 and 45 students were randomly assigned to experimental and control groups, respectively. Nutrition education delivered through e-learning (NeL) was adopted to record students' diets. Online reports with behavioural feedback were provided for the experimental group but not for the control group. NeL sessions lasted for 12 weeks. The energy and nutrient profiles of the students were recorded as pre–post measurements. Pre–post nutrition knowledge was assessed using a self-administered questionnaire at the baseline and after intervention. **Results:** The experimental group had significantly higher scores in the 'dietary recommendation' and 'food choices' domains of the questionnaire and demonstrated significant dietary improvement in the intake of all studied macronutrients and micronutrients. **Conclusions:** Nutrition education conducted with behavioural feedback can effectively improve adolescents' nutrition knowledge and nutritional behaviour.

**Key Words: behavioural feedback, adolescents, nutrition knowledge, nutritional behaviour**

## INTRODUCTION

Meeting the nutritional requirement for growth and development is critical in the puberty stage of adolescents. However, a survey conducted among Hong Kong adolescents aged 12–18 years revealed that 22.3% of boys and 16.7% of girls were underweight, whereas 18.0% of boys and 8.7% of girls were overweight or obese.[1] These statistics are remarkable because the body sizes of adolescents are currently shifting to two unhealthy extremes. Moreover, the increase in the prevalence of diabetes, hypertension, and eating disorders in children has risen severely with an increase in unhealthy body sizes.[2-4] Unbalanced diets, which are common in schoolchildren, could be a factor responsible for this increase in prevalence. In Hong Kong, the younger population prefers to consume desserts, snacks, and fried food.[5] This finding suggests that young children do not understand the importance of healthy eating and that contemporary nutrition education programmes do not effectively provide nutrition knowledge or modify adolescents' nutritional behaviour. Studies conducted in other countries have suggested that inadequate nutrition knowledge in secondary school students is a key determinant of poor health development and functioning.[6] Nutritional behaviour refers to food consumption habits, food choices, and intake of appropriate amount of nutrients.[7] Few studies have investigated the relationship between nutrition knowledge and nutritional behaviour among secondary schoolchildren; however, educating teenagers regarding healthy nutritional behaviour that they may carry forward into their lifestyle in adulthood is a priority.[8]

Technological developments have created innovative opportunities in health education. The role of technology in health education has radically changed from content delivery to learner-focused education, in which knowledge providers decentralise the content and learners contribute to the content in a two-way strategy.[9] Nutrition education can be delivered through an e-learning mode; however, this mode is not as widely used as in other disciplines. Nutrition education is not part of the formal curriculum in Hong Kong schools; instead, it is usually taught through irregular seminars with guest speakers or health educators. In some schools, nutrition education is

**Corresponding Author:** Louisa Ming Yan Chung, Department of Health and Physical Education, The Education University of Hong Kong, 10 Lo Ping Road, Tai Po, New Territories, Hong Kong.
Tel: +852 2948 8584; Fax: +852 2948 7848
Email: chungmy@eduhk.hk
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provided as a part of the Home Economics curriculum and is optional. Nutrition education is still at the stage of seminar-style delivery, which may not be effective in establishing nutritional behaviour and does not enable the continual measurement of nutrition knowledge gained by students and how they reflect on such knowledge. Two reasons for this impediment are lack of resources at the school level and insufficient support at the policy level. E-learning can introduce an efficient platform for empowering students to acquire nutrition knowledge through their ownership of content creation and modifying their nutritional behaviour through behavioural feedback, thereby facilitating the implementation of nutrition education in schools.

### *Theoretical framework*

Knowledge building in this nutrition education programme was supported by behavioural feedback. Behavioural feedback arose from a process in which participants record their daily diet, which experts then appraise and provide feedback on.[10] The provided feedback encourages participants to reflect on their behaviour and ultimately modify their eating habits according to experts' comments. This process is cyclic and emphasises that participants do not follow experts' instructions but instead modify their eating habits on the basis of the comments provided and their own choices regarding food and portion sizes.[11] In the learning process, students create the content by inputting their dietary intake. The behavioural feedback consists of personalised self-evaluation with motivators and reinforcers that are relevant to a person. The results and health educators' comments are converted into reports for students' self-reflection. The determinants of dietary changes constitute the students' decision-making process. The learning and reflective processes eventually reinforce the students to change their nutritional behaviour through personalised nutrition education. This psychological technique of positive and negative reinforcement is central to the theory of behavioural therapy to modify maladapted habits. Positive and negative reinforcement are based on the use of reward and punishment to influence behaviour[12] and are practically applied in self-regulatory motivation.[13]

Behavioural feedback applied in the online dietary system was intensively investigated by the research team. This concept has been reported to be positive in improving eating attitude and nutrition knowledge in obese adults.[14] A theoretical examination was conducted in a recent study.[10] Positive feedback in dietary evaluation encourages students to eat more healthy food, whereas negative feedback discourages them from eating unhealthy food. This indicates that the evaluation of students' food intake conducted by health educators (feedback component) is a result of the students' food intake (behaviour component), and the food evaluation then encourages the students to eat more healthy food or avoid unhealthy food the next day (reflective component). Therefore, this study investigated whether e-learning integrated with behavioural feedback is effective in helping secondary school children to acquire nutrition knowledge and in turn modify their nutritional behaviour.

### *Research hypothesis*

1. Compared with nutrition education delivered through e-learning (NeL) without behavioural feedback, NeL with behavioural feedback more effectively increases the nutrition knowledge of junior secondary students.
2. Compared with NeL without behavioural feedback, NeL with behavioural feedback more effectively modifies the nutritional behaviour of junior secondary students.

## METHODS

### *Design*

This study involved an experimental control design with and without reflective feedback in nutrition e-learning.

### *Sampling and samples*

Invitation letters describing the aim and details of the study were mailed to all secondary schools in Hong Kong. Interested schools were recruited after principals' written replies were obtained. Only secondary schools that did not provide nutrition education in their formal and informal curriculum were recruited, to avoid the effect of prior learning experience on nutrition knowledge. The schools were assigned to an experimental or control group by drawing school numbers, which were set by another researcher. The principal, teachers, and participating students of the schools were blinded to their group of assignment. In total, 95 secondary school children studying from grades 7 to 9 were recruited from five secondary schools. Only students who were of Chinese ethnicity and could read and write in Chinese were included. Students who were required to follow special diets in the 3 months of the study period were excluded.

### *Instrument*

NeL is a concept that entails using recent technological advancements and common Internet applications. A web-based system was programmed to capture food images uploaded by students, thus ensuring more accessible and available records. Body height, body weight, sex, and daily exercise level[15-18] were used to calculate the energy requirement (ER) of each student to provide an energy report based on each student's energy condition.[19] The inputted diets were analysed by health educators by using Nutritionist Pro, Version 5.3, a nutrient analysis software program that contains nutrient data of more than 51,000 foods and ingredients for dietary analyses.[20] The nutrient and energy values of the uploaded food items were entered into the NeL system by health educators. The daily dietary records were programmed as the daily energy intake (EI). An automated comparison of the daily EI and daily ER was conducted according to a formulated scheme programmed in NeL. A reporting function was designed to provide behavioural feedback to the students. Two reports were provided. The first report contained the food profile of each food item to educate students about the energy and nutrient values of each consumed food item. This enabled the students to keep track of specific food items that contain high amounts of unhealthy nutrients such as saturated fat (SFAT), trans fatty acid, and sugar. Through this profiling technique, the students started to acquire knowledge of the actual composition of

the food that they consumed and were educated to gradually minimise or even avoid their intake of unhealthy food. Concurrently, they realised their intake of essential nutrients such as calcium, vitamin C, and dietary fibre. The students discovered the food items containing these essential nutrients and made endeavoured to eat more food rich in these vital nutrients to meet the daily requirement. The second report comprised evaluation feedback based on dietary guidelines. The daily required amounts of nutrients documented from the Centre for Food Safety were used to evaluate whether the nutrient content of the daily dietary input meets the recommended range of values. Through this report, the students learned whether their daily diets were balanced with regard to the suggested guidelines. If the students' intake of vital nutrients was lower than that required level, they were encouraged to meet the requirement by eating more food that contains these nutrients. The previous report on food profiles that listed the nutrient values of foods could be helpful for this, or the students could search for additional nutrition information to find more food items that contain beneficial nutrients. This encouraged the students to take a leading role in knowing their current nutritional status and to be accountable for their eating habits and monitor their nutrition intake. NeL used repeated dietary recording and reporting as a self-monitoring platform to educate students to modify their diets gradually in a desirable and healthy manner. The daily reporting tools in NeL offered useful guides and tips on how to change food choices and food portions. Nevertheless, the students were still able to enjoy flexibility in their food choices as long as the overall dietary plans were considered to be balanced in nutrients. NeL was a modification of an electronic dietary recording system that had already been tested with satisfactory results for reliability (intra-class coefficient=0.916) and accuracy (percentage of agreement range: 50%–100%).[21] In addition, the system had satisfactory usability in the domains of 'System Use', 'Information Quality', and 'Interface Quality'.[19]

### *Outcome Measures*

#### General Nutrition Knowledge

The General Nutrition Knowledge (GNK) questionnaire was developed for assessing a layperson's nutrition knowledge.[22] It comprises 110 multiple-choice and short-answer questions that test participants' knowledge of a sequence of 'dietary recommendations', 'food sources', 'everyday food choices' and 'diet–disease relationships'. A higher number of correctly answered questions indicates higher nutrition knowledge. The GNK has high internal consistency (Cronbach's $\alpha$=0.69, 0.76, 0.8, 0.66 and 0.79 in the 4 respective domains) and test–retest reliability.[23] The Traditional Chinese GNK, back-translated by Peltzer,[24] was used in this study because it has been tested on secondary school students. Comparing students' basic nutrition knowledge before and after the implementation of the nutrition education intervention would be beneficial. The change in nutrition knowledge was an indicator of knowledge transfer from the behavioural feedback provided by NeL. Subscores for the four knowledge domains were collected prior to the project commencement (week 0) and after the project (week 12) from both the experimental and control groups.

#### Nutritional behaviour

Nutritional behaviour was defined as a person's food consumption habits, food choices, and nutrient intake.[7] The participants' baseline measurements such as body height, body weight, and body fat were derived for calculating their ER. Daily energy input and output and nutrient values of carbohydrate (CHO), protein (PRO), SFAT, trans fatty acid, total fat (FAT), calcium, dietary fibre, vitamin C, sugar, and cholesterol at the baseline (mean values in the first week) and at week 12 (mean values in week 12) were collected from both the experimental and control groups.

### *Procedure*

All procedures in this study were approved by the human ethical research committee of Research Development Office, the Education University of Hong Kong (Ref. no. 2013-2014-0010). An information sheet describing the aim and details of the study was distributed to the parents of students studying at levels Secondary 1, Secondary 2, and Secondary 3. Interested students and parents signed a consent form to participate in the study. The students were asked to self-administer the GNK questionnaire as a baseline measurement. Six nutrition lessons were then arranged in a class. The nutrition lessons covered nutrition knowledge regarding food choices, the benefits of common nutrients, diet and diseases, healthy diets, and the relationship between diet and exercise. These six nutrition lessons were aimed at providing the students with basic knowledge of healthy eating and maintaining a healthy lifestyle with exercise. The nutrition lessons were taught by health educators. Each student was then introduced to the NeL system for dietary self-monitoring and assigned an authenticated user number and password to access the system. The students were taught how to use NeL to record their diet every day. Students in both the experimental and control groups were given access to NeL and were requested to record their daily diet in the system by capturing and uploading food photos. They could record their daily diet at home by the end of each day. The nutrient analysis of the food items was conducted by health educators. However, only students in the experimental group received online reports generated after the nutrient analysis. An evaluation was conducted on the control group to determine whether the dietary recording process itself mediates the transfer of nutrition knowledge into nutritional behaviour without the process of reflective learning generated by the reflective feedback. The study design indicated whether the behavioural feedback delivered by NeL was more effective in mediating the transfer of nutrition knowledge into nutritional behaviour. The dietary recording and self-monitoring by the students in both the experimental and control groups lasted for 12 weeks.

### *Statistical analysis*

All the data were analysed using SPSS, Version 21. Independent t test was performed to compare the homogeneity of the physical characteristics of the participants between

**Table 1.** Adolescents' baseline characteristics (n=95)

| Characteristics | experimental group (n=50) Mean (SD) | control group (n=45) Mean (SD) |
|---|---|---|
| Body height | 160.0 (9.91) | 160.3 (8.46) |
| Body weight | 57.0 (14.0) | 55.2 (13.5) |
| Fat % | 26.4 (7.55) | 25.5 (9.59) |

[†]All characteristics were not significant at α=0.05.

the control group and the experimental group. One-way ANOVA was used to examine differences in energy and nutrient profiles at the baseline and postintervention. A criterion-based analysis of the mean values of daily calories and nutrients was conducted using dietary guidelines from the Centre for Food Safety. ANOVA within-between groups was used to analyse the premeasurement and postmeasurement of nutritional behaviour and GNK between the experimental and control groups. The significance level was set at 0.05 (two-tailed).

## RESULTS

In total, five secondary schools were recruited, and 95 junior secondary students agreed to participate in the study with their parents' consent. The percentages of boys and girls were 36.8% (n=35) and 63.2% (n=60), respectively. Of the students, 6.3% (n=6), 74.7% (n=71), and 18.9% (n=18) were classified as underweight, normal weight, and obese, respectively. Table 1 lists the mean body height, mean body weight, and fat percentage of the students assigned to the experimental and control groups. Physical measurements did not significantly differ between the two groups.

### *Nutrition knowledge*

The four domains of nutrition knowledge measured using the GNK questionnaire are presented in Table 2. The results revealed significant improvement in the domains of dietary recommendation and food choices in the experimental group. The mean score of dietary recommendation and food choices increased from 5.94 to 6.74 ($p<0.05$) and from 4.16 to 5.14 ($p<0.05$), respectively. No improvement was observed in the domains of food sources and diet–disease relationships in the experimental group.

The results of the GNK questionnaire revealed significant declines in the domains of food sources and diet–disease relationships in the control group. The mean scores of food sources and diet–disease relationships significantly decreased from 33.81 to 28.22 ($p<0.05$) and from 5.41 to 3.81 ($p<0.05$), respectively. No improvement was observed in the domains of dietary recommendation and food choices in the control group.

The corresponding group effects on the domains of dietary recommendation, food sources, food choices, and diet–disease relationships were $F(1,80)=1.618$ ($p>0.05$, $\eta 2=0.02$), $F(1,80)=4.02$ ($p<0.05$, $\eta 2=0.048$), $F(1,80)=4.255$ ($p<0.05$, $\eta 2=0.05$), and $F(1,80)=4.502$ ($p<0.05$, $\eta 2=0.053$), respectively. According to the guidelines of Cohen,[25] the effect size of food choices and diet–disease relationships was moderate.

### *Nutritional behaviour*

The pretest and posttest nutritional behaviour of the two groups are presented in Table 3. The recommended EI for adolescents aged 13–15 years is 2200 kcal/day.[6] The results revealed that the daily EI of the students in both study groups was below the daily requirement. After the intervention period, both groups exhibited an increase in their EI levels; however, the students in the experimental group exhibited significant improvement after the intervention ($p<0.05$). According to the recommended guidelines of daily diet for adolescents, the percentages of CHO, PRO, FAT, and SFAT consumption should be at least 55%, 10%–15%, 15%–30%, and less than 10% of the daily EI, respectively.[6] Based on these guidelines, the nutritional behaviour of both the experimental and control groups did not meet the healthy eating criteria for macronutrients. In the experimental group, the intake levels of CHO, PRO, FAT, and SFAT were improved, and SFAT intake barely reached the upper limit of the recommended daily consumption. In the control group, no improvement was observed in the daily intake of macronutrients. The daily intake of macronutrients significantly differed between the experimental and control groups.

For adolescents aged 13-15 years, the recommended daily intake of micronutrients such as trans fatty acid, cholesterol, sodium, and sugar should not be more than 2 g, 300 mg, 2,000 mg, and 55 g, respectively. The dietary analysis indicated that the pretest daily intake values in both groups exceeded the highest tolerance limits of these

**Table 2.** Adolescents' baseline characteristics (n=95)

| Domains in GNK | Baseline measurement Mean (SD) | Post measurement Mean (SD) | Difference[†] Mean (SD) |
|---|---|---|---|
| Experimental group | | | |
| Dietary recommendation | 5.94 (2.02) | 6.74 (1.41) | -0.80 (2.00)[*] |
| Food sources | 33.3 (11.3) | 34.0 (16.3) | -0.66 (13.3) |
| Food choices | 4.16 (1.90) | 5.14 (1.60) | -0.98 (2.06)[*] |
| Diet-disease relationships | 4.86 (3.32) | 4.84 (4.28) | 0.02 (3.09) |
| Control group | | | |
| Dietary recommendation | 5.19 (2.416) | 5.31 (3.15) | -0.13 (2.81) |
| Food sources | 33.8 (14.4) | 28.2 (18.9) | 5.60 (14.5)[**] |
| Food choices | 3.84 (1.37) | 3.91 (1.89) | -0.06 (1.81) |
| Diet-disease relationships | 5.41 (3.07) | 3.81 (3.52) | 1.59 (3.56)[**] |

[†]Mean difference = mean (baseline measurement – post measurement).
[*]Significant increases were shown at $p<0.05$.
[**]Significant decreases in scores were shown at $p<0.05$.

**Table 3.** Dietary records of nutritional behaviour

| | Experimental Group | | Control Group | | Group effect | |
|---|---|---|---|---|---|---|
| | Pre-test Mean±SD | Post-test Mean±SD. | Pre-test Mean±SD | Post-test Mean±SD | F | *p* |
| Energy (kcal/day) | 1797±437 | 1926±262 | 1980±401 | 2070±424 | 4.10 | <0.05 |
| Percentage (%)† | | | | | | |
| Carbohydrate | 29.0±13.9 | 30.7±12.4 | 25.3±7.50 | 22.5±6.72 | 15.7 | <0.01 |
| Protein | 19.8±7.12 | 16.3±5.66 | 20.3±6.12 | 21.9±8.07 | 15.6 | <0.01 |
| Total fat | 40.7 ±10.3 | 32.7±9.85 | 39.6±10.1 | 39.2±9.96 | 10.1 | 0.02 |
| Saturated fat | 13.2±4.43 | 10.9±3.66 | 15.3±7.44 | 16.5±5.87 | 32.3 | <0.01 |
| Trans fatty acid (g/d) | 3.55±1.85 | 1.94±0.90 | 3.10±1.01 | 3.24±1.03 | 43.2 | <0.01 |
| Dietary fibre (g/d) | 10.7±4.20 | 19.4±6.77 | 11.6±4.11 | 11.4±4.46 | 44.2 | <0.01 |
| Calcium (mg/d) | 261±157 | 479±270 | 292±187 | 284±159 | 17.9 | <0.01 |
| Cholesterol (mg/d) | 431±192 | 292±210 | 476±173 | 486±159 | 25.2 | <0.01 |
| Sodium (mg/d) | 2800±1286 | 2131±692 | 2743±872 | 2802±691 | 22.3 | <0.01 |
| Sugar (g/d) | 51.8±23.6 | 35.2±11.1 | 51.8±20.6 | 55.3±23.2 | 29.8 | <0.01 |
| Vitamin C (mg/d) | 20.5±11.5 | 31.4±14.4 | 20.8±10.1 | 18.7±7.19 | 28.3 | <0.01 |

†For carbohydrate, percentages were calculated as (actual carbohydrate intake × 4 kcal/actual daily calorie intake) × 100%.
For protein, percentages were calculated as (actual protein intake × 4 kcal/actual daily calorie intake) × 100%.
For total fat, percentages were calculated as (actual total fat intake × 9 kcal/actual daily calorie intake) × 100%.
For saturated fat, percentages were calculated as (actual saturated fat intake × 9 kcal/actual daily calorie intake) × 100%.

micronutrients, except for sugar. After the intervention, the daily intake of trans fatty acid, cholesterol, sodium, and sugar in the experimental group significantly improved, compared with that in the control group (all $p<0.001$). The daily intake of dietary fibre, calcium, and vitamin C significantly increased in the experimental group ($p<0.001$). However, this increase was still below the recommended daily intake levels of 30 g, 1300 mg, and 65 mg, respectively.

## DISCUSSION

Adolescence is a crucial time of life for the strengthening of sound nutritional behaviour and ratification of potential nutritional deficiencies for growth because adolescents are less cautious of their health to prevent diseases and risk factors. In particular, early introduction of healthy nutritional behaviour in adolescent girls may reduce their risk of osteoporosis in older age and increased prepregnancy weight, in addition to ensuring improved iron and folate status in pregnancy. However, adolescence is regarded as a vulnerable period for intake of adequate nutrition; this is because adolescence is a transient stage of growth from childhood to adulthood and adolescents have poor eating patterns. According to the World Health Organization reference,[26] the body weight and body height measured among the male adolescents were in 1 S.D. from the age-specific norm; whereas those measured among the female adolescents were within the age-specific norm. The findings showed the participated male adolescents were in heavier body weight as compared to other same age counterpart. An increase in ER during puberty requires higher intake of PRO, calcium, and other vitamins and minerals because they are critical for gaining muscle and bone mass. Nevertheless, to prevent obesity, the energy intake and amount of consumed FAT should not be excessive. In addition, the intake of trans fatty acids, cholesterol, sodium, and sugar should be lowered to prevent cardiovascular diseases, hypertension, and diet-related cancers. Our study results confirm the commonly raised dietary issues of adolescents that they have inadequate energy intake as compared with the recommended 2200 and 1800 kcal/day for boys and girls, respectively, in midadolescence. The results revealed that the students consumed less than 30% CHO, the recommended consumption level of which should be at least 55%. However, the students consumed more than the recommended percentages of PRO, FAT, and SFAT. Other micronutrients were also found in a lower recommendation than the recommended daily intake of their ages. The observed findings are indicative of adolescents' nutritional gaps in achieving healthy diet. For girls, it would also be a potential risk when nutrient deficiencies continued and occurred in late adolescents and by then it could be the optimal time for pregnancy. Pregnant adolescent if occurred with poor prenatal care is a concern because inadequate gestational weight gain causes further medical complications like foetal death and low birth weight. Competition for nutrients between the foetus and the young mother has been documented with its association in restricted foetal growth, risk of miscarriage and preterm delivery.[27] Suboptimal nutritional intakes for calcium were found in this study and other previous studies in teenagers. In fact, calcium is the highest rate that approximately 25-30 g per day is required to support fetal growth in skeleton.[28] This transferred amount of calcium is more important when the pregnancy enters the last trimester. Recent report showed that mothers should intake more than 1050 mg per day to ensure foetal birth in normal length because calcium is crucial to the femur and humerus growth and development.[29] In this connection, calcium absorption among the adolescents did address both maternal and foetal health risks. Effective nutrition education implemented at schools are highly recommended as strategies to warrant early behavioural change.

We observed that these nutrition education is important for school students improving nutrition knowledge. We found that the mean GNK questionnaire scores of the secondary students assessed in this study were lower than those of adults reported in a previous study,[14] indicating that the secondary students were not adequately equipped with nutrition knowledge for matching their daily nutritional requirements for growth and disease prevention. Inadequate nutrition knowledge accompanied by unsatisfactory nutritional behaviour implied the students' lack of knowledge regarding dietary recommendation and food choices. The gap between the assessed intake values of trans fatty acid, dietary fibre, calcium, cholesterol, sodium, and vitamin C and those recommended indicates that the students could not relate various nutrients to different food sources. After the 12-week learning experience with NeL, the students in the experimental group exhibited significant improvement in the knowledge area of dietary recommendation and food choices, and they were found capable to modify their eating patterns for the studied macronutrients and micronutrients. However, such improvement was not observed in the control group. In addition, the mean scores of food choices and diet–disease relationships significantly decreased in the control group. These findings suggest that nutrition education without individual reflection cannot internalise nutrition knowledge. The approach of dietary recording cannot imprint a sufficient impact on the nutrition knowledge gained by the secondary students. However, the approach of reflective learning with students identifying their eating problems and correcting their chosen actions may provide critical clues in the role of behavioural feedback.

Nutrition education designed for adolescents should be unique to address their food access and dietary inquiry. Their problems in dietary patterns should be channelled to them as feedback for action. Their eating problems should be easily traced in their dietary records and dietary analyses, and immediate correction should be accordingly made in their meal plans. To facilitate such interactive learning, NeL with reflective feedback can provide this reflective learning in adolescents. The research design in this study was trying to differentiate the inclusion of reflective learning process, but not the adoption of NeL. Adolescents' self-reflection is critical to the change of behaviour. They should take their own control in identifying the eating problems and correcting their eating problems by proper food choices. The results of this study support the hypothesis that nutrition knowledge in the domains of dietary recommendation and food choices can be improved by the proposed NeL with a behavioural

feedback approach. Because arguments are frequently raised in the transferable behaviour from knowledge to behaviour, this study then compared the dietary analysis in a mixed pre–post design. Although the 12-week nutrition education programme along with the dietary recording and reflective process was not long enough to be sufficient to convert the dietary patterns of the adolescents to healthy eating habits, the proposed approach can still effectively shape their eating habits towards the recommended eating guidelines. This can promote healthy eating and can be a beneficial step for adolescents.

### *Implications and contribution*

Nutrition education delivered in eLearning brings the feature of behavioural feedback (NeL). Findings suggest that NeL enhances adolescents' nutrition knowledge in dietary recommendation and food choices. The increased nutrition knowledge is also found transferrable to the improved nutrition behaviour which is important to reduce risks in growth and development.

### *Conclusion*

Nutrition education involving behaviour feedback can effectively improve adolescents' nutrition knowledge and nutritional behaviour.

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**AUTHOR DISCLOSURES**

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