Enliven Archive
Intensifying Thoughts

Research Article www.enlivenarchive.org Enliven: Journal of Dietetics Research and Nutrition

ISSN: 2378-5438

Online College Energy Balance Course Improves Determinants of Behavior and Student Knowledge

Simonne M. Eisenhardt, PhD[1], Linda Berlin, PhD[1], Regina Toolin, PhD[2], and Stephen J. Pintauro, PhD[1*]

[1]Department of Nutrition and Food Sciences, University of Vermont, USA

[2]Department of Education, University of Vermont, USA

[*]**Corresponding author**: Dr. Stephen J. Pintauro, PhD, Department of Nutrition and Food Sciences, 230 Marsh Life Sciences, University of Vermont Burlington, VT 05405, USA; E-mail: Stephen.pintauro@uvm.edu

Received Date: 03rd April 2015
Accepted Date: 17rd April 2015
Published Date: 24th April 2015

Citation: Eisenhardt SM, Berlin L, Toolin R, and Pintauro SJ (2015) Online College Energy Balance Course Improves Determinants of Behavior and Student Knowledge. Enliven: J Diet Res Nutr 2(1): 002.

Abstract

The objectives of this study were to (a) determine the effectiveness of a science-based, online, interactive, energy balance course and intervention at improving energy balance knowledge and determinants of behavior associated with eating a healthy diet and meeting physical activity recommendations and (b) to assess to what extent applications of behavioral theory are perceived by students to influence their knowledge and motivation/ability to eat a healthy diet and meet physical activity recommendations. A framework of behavioral theory was used to guide the selection of course strategies to improve goal-setting and self-regulation skills and to improve self-efficacy toward eating a healthy diet and meeting physical activity recommendations. A quasi-experimental study design was used to compare the responses to pre/post energy balance knowledge assessments and self-perceptions surveys of course participants (33) and non-course participants (26) ages 18 to 25. Paired samples t-tests compared pre/post responses to knowledge assessments and self-perception surveys. Independent samples t-tests compared mean changes in responses of the participants and the non-participants. Significant increases were observed in energy balance knowledge ($P < 0.001$), attitude ($P = 0.006$), and perceived behavioral control ($P = 0.004$) toward eating a healthy diet in the course participants when compared to course non-participants. Diet and physical activity recalls and analysis were perceived by students to have the greatest influence on motivation/ability to engage in targeted behaviors. The results of this study demonstrate that a science-based, online, interactive, energy balance course developed from behavioral theory can be effective at improving energy balance knowledge and dietary attitude and perceived behavioral control.

Keywords: Online; College course; Energy balance; Behavioral theory; Interactive

Introduction

For many Americans, few events will impact their lives as significantly as the transition from high school to college. During this transition, young adults characteristically experience an increase in independence, responsibility and freedom of choice that often results in significant and sometimes unfavorable lifestyle changes [1]. For many, these changes include a reduction in physical activity levels or the adoption of unhealthy dietary behaviors. These adverse changes to energy balance variables can result in significant energy imbalances and weight gain [2,3]. Preparing students with the tools, skills and support necessary to cope with these unanticipated challenges may promote the adoption of healthier lifestyles and foster sustained healthier diet and physical activity choices throughout the college years [4].

Improving nutrition and physical activity behaviors through college-level nutrition and health education programs is a strategy used in some interventions. Increasing physical activity awareness through participation in an introductory fitness course using pedometers has been shown to result in increased physical activity among college students [5]. Similarly, participation in a traditional nutrition education course can result in improved dietary behaviors [6], presumably due to an increase in nutrition knowledge, as a higher level of nutrition knowledge is often associated with consuming a healthier diet [7]. Participating in a online nutrition course emphasizing increased dairy consumption has also been shown to improve determinants of behavior as a result of increases in self-efficacy and self-regulatory skills associated with dairy consumption [8].

Learning environments that offer opportunities for transactions between the individual and their environment can promote a deeper understanding of concepts through experiential learning [9]. By actively participating in the learning process, individuals transform experiences into more comprehensive understandings through their adaptations to these experiences. In nutrition education, participation in an online interactive learning environment designed to promote healthy diet and physical activity behaviors has been shown to promote nutrition knowledge, healthy dietary behaviors and reduce perceived barriers to physical activity when compared to controls [10]. However, to our knowledge no published studies have examined the effectiveness of an online college-level nutrition education course, build around the constructs of behavioral theory. This approach may help guide the development of health-related online courses that are designed to both increase student knowledge, as well as improve health behaviors.

Use of behavioral theory as a framework for understanding the behaviors of populations can support the design and development of effective interventions for the promotion of behavioral change [11]. In nutrition education, behavioral theory can offer a deeper understanding of the determinants of behavior, promote the selection of appropriate, evidence-based strategies and support the development of tools for the evaluation of psychosocial change [12]. The theory of planned behavior (TPB), a commonly used theory in behavioral research, posits that our beliefs associated with a behavior help to form our attitudes, subjective norms and perceived behavioral control (self-efficacy and controllability) towards engaging in the behavior [13]. These determinants further influence our intentions to engage in the behavior. In young adults, perceived behavioral control has been shown to have the strongest influence over intentions to eat a healthy diet [14], while self-efficacy has been shown to have the strongest influence over intentions to engage in regular exercise [15].

Social cognitive theory (SCT), another commonly used theory in behavioral research, posits that our behavioral choices result from reciprocal influences that occur naturally between personal factors, including outcome expectations, self-efficacy and goal-setting, behavioral factors, including knowledge and skills, and environmental factors [16]. Through modeling or actively engaging in a behavior, individuals formulate more accurate conceptions of the behavior that result in adjustments to personal and behavioral factors associated with the behavior [17]. Changes in these factors can influence motivation to engage in behaviors. Of the personal determinants, self-efficacy is thought to play the most critical role in motivating behavior [18]. In health promotion, self-efficacy can play a central role in motivating and sustaining action toward engaging in healthy behaviors [19].

Consistent with behavioral theory and the process of experiential learning, a science-based, interactive online energy balance course was designed and developed to improve energy balance knowledge and determinants of behavior towards eating a healthy diet and engaging in the recommended amount of physical activity. The purpose of this study was (a) to determine the effectiveness of this course and intervention at increasing energy balance knowledge and improving determinants of behavior towards eating a healthy diet and engaging in the recommended amount of physical activity and (b) to assess to what extent the applications of behavioral theory were perceived by students to influence student knowledge and motivation/ability to eat a healthy diet and meet physical activity recommendations.

Methods and Materials

A two-week, online, science-based, interactive, energy balance course was designed using the TPB and SCT as guides in the development of the course content and the selection of applications of behavioral theory (Table 1). Scientific concepts introduced in the curriculum included; basic processes of energy transformation, metabolism and functions of select nutrients, and environmental and biological influences associated with energy balance. Required assignments included 3-day diet and physical activity recalls, diet and energy balance analysis and the preparation of an action plan.

A knowledge assessment, consisting of 25 multiple-choice questions, was developed from the curriculum to assess energy balance knowledge. Use of Blooms Taxonomy [20] and a table of specifications [21] supported congruency between the curriculum and assessment questions and alignment with learning objectives. The assessment was reviewed by a panel of peers for content validity. One question was replaced due to ambiguity. Further analyses included split-half internal consistency testing ($r = 0.69$) for reliability and item analyses including facility value and discrimination index testing [22].

A self-perception survey, developed from a framework of the TPB [23], was used to assess intentions, attitude, subjective norms and perceived behavioral control (PBC) toward eating a healthy diet and engaging in the recommended amount of physical activity (Table 2). The survey was evaluated for reliability and modified prior to beginning the research. An internal consistency value could not be calculated for the diet intentions measure, as the pre- and post-intervention responses to one item of the two-item measure were identical in reliability tests. A two-item measure assessed physical activity intention (Cronbach's $\alpha = 0.85$). Diet and physical activity attitudes were assessed using three single item measures, as each was found to measure independent attitude judgments towards eating a healthy diet and engaging in the recommended amount of physical activity. Diet subjective norms were assessed using a three-item measure (Cronbach's $\alpha = 0.73$). An internal consistency value could not be calculated for the physical activity subjective norms measure, as one of the items in the two-item measure was eliminated due to a typographical error. Finally, a four-item measure assessed diet and physical activity PBC (Diet Cronbach's $\alpha = .87$, Physical activity Cronbach's $\alpha = 0.81$).

A course evaluation was developed to solicit student feedback of the online course and to assess to what extent the applications of behavioral theory supported concepts presented in the curriculum and/or increased student motivation/ability to eat a healthy diet and meet physical activity recommendations. The course evaluation, a demographics survey and identical pre- and post-intervention energy balance knowledge assessments and self-perception surveys were completed by students as course requirements.

Table 1. Course applications of behavioral theory

TPB & SCT Construct / Mediator	Applications of Behavioral Theory
Attitude/ Outcome Expectations	**Lessons:** improve knowledge, attitude, and outcome expectations toward healthy diet and physical activity behaviors through positive messages and correcting misconceptions.
	Professional Interviews: reinforce positive messages and offer professional support for healthy diet and physical activity behaviors.
	Diet & Physical Activity Recalls: support positive self-evaluation of diet and physical activity behaviors.
Subjective Norms/ Social Outcome Expectations	**Peer Interviews and Images**: model social support for healthy diet and physical activity behaviors and promote positive social outcome expectations.
Perceived Behavioral Control/Self-Efficacy	**Diet & Energy Balance Analysis**: increases skills in diet and physical activity analysis for the promotion of self-efficacy.
	Interactive Activities: promote skills, confidence and mastery experiences in choosing a healthy diet and improving physical activity behaviors for the promotion of self-efficacy.
	Lessons: promote problem solving skills and increase awareness of common barriers to healthy diet and physical activity behaviors for stimulus control and to prevent relapses.
Self-Regulation	**Diet & Energy Balance Analysis**: supports skills in self-regulation and establish goals for the promotion of healthy diet and physical activity behaviors. **Action Plan**: supports skills in goal setting and motivate action. **Lessons**: increase awareness and skills in self-monitoring.

Table 2. Diet and physical activity self-perception surveys on a 1-5 Likert scale.

Diet Survey Preface: "*...a Healthy Diet is defined as a daily eating pattern that includes multiple servings of fruit and vegetables, fiber and whole grains, while limited in saturated fats, added sugars, and salt*." Physical Activity Survey Preface:"*...for adults, at least 150 minutes (2 hours and 30 minutes) a week of moderate-intensity, or 75 minutes (1 hour and 15 minutes) a week of vigorous-intensity physical activity is recommended*."		
Determinant	Item	Scale
Intention	*"In the future, I intend to eat a healthy diet/engage in the recommended amount of physical activity."*	*"Very Unlikely" to "Very Likely"*
	"In the future, I want to eat a healthy diet/engage in the recommended amount of physical activity."	*" Strongly Disagree" to "Strongly Agree"*
Attitude	*"My eating a healthy diet/engaging in the recommended amount of physical activity in the future would be/is..."*	*"Very Unnecessary" to "Very Necessary" a* *"Very Pleasant" to "Very Unpleasant"* *"Very Good" to "Very Bad"* *"Very Unenjoyable" to "Very Enjoyable" b*
Subjective Norm	*"Most people who are important to me think that I should eat a healthy diet in the future/engage in the recommend amount of physical activity."*	*"Strongly Disagree" to "Strongly Agree"*
	"It is expected of me to eat a healthy diet in the future/ engage in the recommended amount of physical activity."	*"Strongly Disagree" to "Strongly Agree"*
	"People in my life, whose opinions I value, think that I should eat a healthy diet in the future/engage in the recommended amount of physical activity."	*"Strongly Disagree" to "Strongly Agree"*

Perceived Behavioral Control	*"For me to eat a healthy diet/engage in the recommended amount of physical activity in the future would be…"*	*"Very Difficult" to "Very Easy"*
	"If I wanted to, I could eat a healthy diet/engage in the recommended amount of physical activity in the future."	*"Strongly Disagree" to "Strongly Agree"*
	"How much control do you believe you have over eating a healthy diet/engaging in the recommended amount of physical activity in the future?"	*"No Control to "Complete Control"*
	"I am sure/confident that I can eat a healthy diet/engage in the recommended amount of physical activity in the future."	*"Strongly Disagree" to "Strongly Agree"*
[a] Diet survey only. [b] Physical activity survey only.		

The two-week online, energy balance course was offered for one credit through UVM's Department of Nutrition and Food Sciences. Registration was open to all university students as well as the general public through the University's Division of Continuing Education. Enrolled students were invited to participate in this research study associated with the course, without benefit, but could elect to not participate, without penalty. Eligible students were 18 to 25 years of age and had not completed a nutrition course prior to the study. The Committee on Human Research in the Behavioral Sciences at the University of Vermont approved the research protocol in an expedited review of the study. Implied consent was obtained from students with the completion of initial assessments.

A control group of students were recruited, through on-campus posters, to participate in the study as members of the comparison group. Eligible students were 18 to 25 years of age and had not enrolled any nutrition course prior to the study. Participants received a US$20 gift certificate to the University Bookstore after completing an online demographics survey and two identical energy balance knowledge assessments and self-perception surveys administered two weeks apart. These assessments were identical to those administered to students in the intervention "online class" group.

All data, including survey and reliability testing, were analyzed using IBM SPSS Statistics for Windows, Version 22.0, (IBM Corp., Armonk, NY). All data were collected in databases through online surveys and programs. Identifiable data were replaced with randomly-generated identifiers prior to analysis. The BMI for each student was calculated using self-reported data for height and weight. Two-tailed, independent samples t-tests and Chi-square tests were conducted to determine if demographic data differed significantly between course participants and the comparison group. Responses to initial self-perception surveys from course participants and students in the comparison groups were compared using two-tailed independent samples t-tests to determine if there were statistical differences in determinants of behavior at baseline. Two-tailed, paired samples t-tests were conducted to compare pre- and post-course responses of course participants to knowledge assessments and self-perception surveys and to compare responses to the same assessments and surveys taken two weeks apart from the students in the comparison group. Cross tabulation analyses were conducted to determine the nature of the changes in responses to self-perception survey items in both groups. Differences were considered significant at $P < 0.05$. Subsequent two-tailed, independent samples t-tests were conducted to compare the mean changes in responses to knowledge assessments and self-perception surveys between the course participants and the students of the comparison group. Course evaluation responses were reviewed to determine the perceived influence of applications of behavioral theory on knowledge and motivation/ability to engage in targeted behaviors.

Results

A total of 49 students completed the two week online, energy balance course. Fifteen of these students were ineligible for the study, as they had previously completed a nutrition course (14) or exceeded the age limit (1). One student chose not to participate in the study. This resulted in a total of 33 students from the online, energy balance course group included in the analysis. Twenty six students participated in the study as members of the comparison group. No statistical differences in demographics, health majors and college year were found between the course participants and the comparison group (Table 3).

Table 3. Demographic characteristics of course participants and comparison group.

	Participants n = 33	Comparison n = 26
Age Mean (SD) [a]	20.1 (1.6)	19.5 (1.6)
Gender [b]		
Male (%)	7 (21)	4 (15)
Female (%)	26 (79)	22 (85)
BMI Mean (SD) [a]	23.3 (4.7)	21.7 (3.6)
Male Mean (SD)	26.1 (7.4)	24.4 (2.5)
Female Mean (SD)	22.5 (3.5)	21.3 (3.7)
College Major [b]		
Health (%) [c]	1 (3)	2 (8)
Non-Health (%)	32 (97)	24 (92)
College Year [b]		
Freshman (%)	11 (33)	9 (35)
Sophomore (%)	3 (9)	8 (31)
Junior (%)	5 (15)	3 (12)
Senior (%)	14 (42)	6 (23)
Ethnicity/Race [b]		
Caucasian (%)	24 (73)	23 (88)
Non-Caucasian (%)	9 (27)	3 (12)

*No significant differences between the groups at $p < 05$.
[a] Two-tailed independent samples t-tests.
[b] Chi-square tests to determine if there is a statistical difference between the course participants and the comparison group.
[c] Health Majors included: Nutrition, Nursing (3).

Significant differences in baseline self-perception survey responses were found between the course participants and the comparison group (Table 4). A more favorable attitude associated with the adjective pairs "Very Unpleasant" to "Very Pleasant" was observed in the course participants toward eating a healthy diet (P = 0.04) and engaging in the recommended amount of physical activity (P = 0.04). Moreover, course participants were found to have greater PBC (P = 0.02) toward engaging in the recommended amount of physical activity.

Significant differences were observed between the course participants and the comparison group in pre- to post- mean changes in responses to knowledge assessments and self-perception surveys (Table 4). A significant increase in energy balance knowledge was observed in course participants when compared to the comparison group (P < 0.001). A significant difference was observed between the course participants and the comparison group in attitude associated with the adjective pairs "Very Good" and "Very Bad" (P = 0.006) toward consuming a healthy diet. A significant difference was also observed between the course participants and the comparison group in PBC (P = 0.004) toward consuming a healthy diet. The changes associated with this outcome included improvements in 28% of the responses to the PBC item measure in course participants and a decline in PBC for 25% of the responses in the comparison group to the PBC item measure. (Cross tabulation data not shown).

Table 4. Comparison of mean changes in knowledge and determinants of behavior between course participants and comparison group.

	Course Participants n = 33			Comparison Group n = 26			
	Pre-Test mean (SD)	Post-Testmean (SD)	Mean Change	Pre-Test mean (SD)	Post-Testmean (SD)	Mean Change	P- Value [b]
Knowledge (% correct)	62.2 (11.2)	82.6 (11.7)	20.4 (10.1)	61.1 (17.1)	58.3 (18.2)	-2.8 (15.8)	< 0.001
Diet [a]							
Intentions (2 items)	4.7 (.53)	4.8 (.51)	0.1 (.24)	4.7 (.51)	4.6 (.71)	-0.1 (.66)	0.21
Attitude (3 single items)							
"Very Necessary to Very Unnecessary"	4.4 (.83)	4.5 (.67)	0.1 (.61)	4.6 (.58)	4.6 (.50)	-0.0 (.49)	0.68
"Very Pleasant to Very Unpleasant"	4.4 (1.1) [c]	4.6 (.75)	0.2 (.74)	3.8 (1.1) [c]	3.7 (1.2)	-0.1 (1.3)	0.23
"Very Good to Very Bad"	4.8 (.49)	4.9 (.42)	0.1 (.38)	4.9 (.27)	4.6 (.64)	-0.3 (.68)	0.006
Subjective Norms (3 items)	4.0 (.93)	4.3 (.71)	0.3 (.72)	4.1 (.91)	4.2 (.81)	0.1 (.68)	0.26
PBC (4 items)	4.1 (.72)	4.4 (.59)	0.3 (.51)	4.0 (.70)	3.9 (.71)	-0.1 (.42)	0.004
Physical Activity[a]							
Intentions (2 items)	4.7 (.59)	4.9 (.28)	0.2 (.55)	4.4 (.84)	4.5 (.65)	0.1 (.44)	0.26
Attitude (3 single items)							
"Very Pleasant to Very Unpleasant"	4.3 (.88) [c]	4.3 (.78)	0.0 (.85)	3.7 (1.2) [c]	3.9 (.88)	0.1 (.95)	0.72
"Very Good to Very Bad"	4.9 (.44)	4.9 (.44)	0.0 (.61)	4.7 (.67)	4.7 (.75)	-0.1 (.74)	0.67
"Very Enjoyable to Very Unenjoyable"	3.7 (1.4)	3.9 (1.4)	0.2 (1.9)	3.6 (1.3)	3.5 (1.2)	-.01 (1.3)	0.60
Subjective Norms (1 item)	4.1 (.98)	4.3 (.77)	0.2 (.78)	3.9 (.86)	4.4 (.75)	0.5 (.71)	0.15
PBC (4 items)	4.4 (.55) [c]	4.6 (.48)	0.1 (.38)	4.0 (.81) [c]	4.2 (.62)	0.2 (.49)	0.69

PBC: perceived behavioral control.

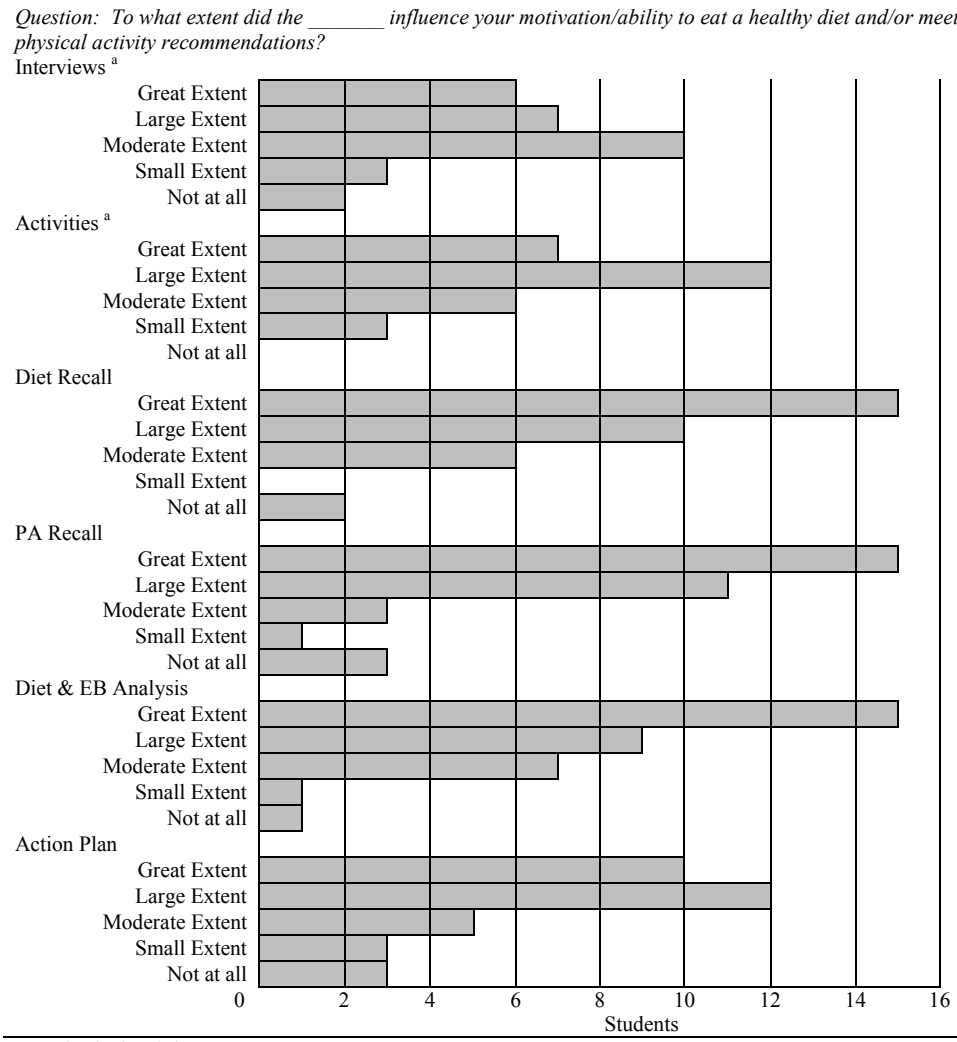
[a] Values represent mean scores on a five point Likert scale.

[b] Two-tailed, independent samples t-tests comparing mean changes between course participants and comparison group.

[c] Significantly different determinants of behavior at baseline between the course participants and comparison group at P < .05.

In course evaluations, over 96% of the students believed that the curriculum had increased their general nutrition knowledge from a moderate to great extent. Approximately 82% of the students reported that the lesson activities supported the concepts in the lesson from a moderate to great extent. Students also reported that several applications of behavioral theory were perceived to influence their motivation/ability to eat a healthy diet and meet physical activity recommendations from a moderate to a great extent (Figure 1).The applications of behavioral theory that were perceived to be most influential in motivating behavior included the diet recalls, physical activity recalls and the diet and energy balance analysis. Although perceived to be less influential, the remaining applications of behavioral theory, including the action plan, interactive activities and peer and professional interviews, were perceived to influence motivation/ability to engage in targeted behaviors from a moderate to a great extent for more than 68% of the students.

Figure 1. Perceived influence of applications of behavioral theory on student motivation/ability to eat a healthy diet and/or meet physical activity recommendations.



PA: physical activity.
EB: energy balance.
[a] Five students responded "Not sure".

Discussion

The online, interactive, energy balance course was effective at increasing energy balance knowledge in a college population. This outcome is consistent with other studies, where an increase in nutrition knowledge was observed as a result of student participation in an online, college-level nutrition course [24]. Moreover, the use of an online format in nutrition education has been shown to be as effective at increasing nutrition knowledge as a traditional lecture format [25] and is accepted among students and health experts alike, particularly when the content is designed to address the issues and needs of the student population [26].

The effectiveness of this intervention at significantly increasing energy balance knowledge may be partially attributable to the science-based design of the curriculum, as it may have fostered a deeper understanding of energy balance and the physiological and metabolic impact of diet and physical activity behaviors. The interactive design of the program may also have supported the significant increase in energy balance knowledge through active learning. Research comparing the effectiveness of online active learning to expository learning in the promotion of knowledge is mixed [27]. However, in this study, four out of five students reported that the interactive lesson activities supported the concepts in the lesson from a moderate to great extent. Finally, the course grading structure may have incentivized a greater understanding of energy balance knowledge, as the post-intervention knowledge assessment scores were used to calculate the students' final grade in the course. Although this may have resulted in higher scores than if the same intervention were implemented outside of a college setting, the greater increases in knowledge may offer support for the integration of health interventions in college courses.

The intervention was also found to be effective at improving determinates of behavior associated with eating a healthy diet and less effective at improving determinants of behavior associated with engaging in the recommended amount of physical activity. This result may be attributable to the course content, as it focused more on improving dietary behaviors than physical activity behaviors. The smaller gains associated with physical activity in our study may have also been a consequence of setting the standard too high; students may have perceived "engaging in the recommended amount of physical activity" as too daunting a task. However, in baseline self-perception comparisons, students who elected to participate in the course intervention reported stronger attitudes and PBC toward engaging in the recommended amount of physical activity than students in the comparison group. This may have resulted in an underestimation of the effectiveness of the intervention at improving determinants of behavior associated with physical activity in a general college population.

While the study of Franko et al. [10] demonstrated that a brief online nutrition education program can improve some nutrition behaviors, our study further demonstrated that specifically designing the course around constructs of the Theory of Planned Behavior and the Social Cognitive Theory can improve nutrition knowledge as well as dietary attitudes and perceived behavioral control. The effectiveness of the intervention at improving attitudes and increasing PBC towards consuming a healthy diet may be attributable to the curriculum design, increased dietary awareness and skills resulting from the use of applications of behavioral theory. The science-based design may have promoted increased awareness of the personal relevance of nutrient and physical activity recommendations. This presumption is supported by previous research where a science-based college nutrition course was effective at promoting energy balance among female freshman with a BMI > 24 when compared to controls [28]. Diet and physical activity recalls and energy balance and diet analysis assignments may have increased awareness of the need to change and developed skills in selecting healthier food items and physical activity behaviors. Support for activities that promote increased dietary awareness is seen in recent research where most students in a traditional nutrition course believed an online dietary analysis program would be effective at motivating peers to improve their dietary behaviors [29]. Additional support for the use of these applications of behavioral theory in nutrition interventions is seen in this study where the majority of students perceived the interactive activities, diet, and physical activity recalls, diet and energy balance analysis assignment, and the preparation of an action plan to have influenced their motivation/ability to eat a healthy diet and meet physical activity recommendations from a moderate to a great extent. Further, student skills and self-efficacy in goal-setting may have also been increased as a result of developing an individualized action plan. An increase in skills and self-efficacy may also explain the significant differences observed between the course participants and the comparison group with regard to attitude toward consuming a healthy diet. Here a 12% increase in more favorable responses to the item measure "Very Good" to "Very Bad" was observed in course participants while a 27% decrease in favorable attitude responses was observed in the comparison group. Perhaps the skills and self-efficacy acquired during the course helped course participants cope with daily dietary challenges, while non-course participants were discouraged over the same period of time due to a lack of skills and self-efficacy.

Although intentions and determinants of behavior are not direct measures of behavioral change, intentions and PBC have been shown to be predictive of some health behaviors. In a meta-analysis, researchers found the TPB to be predictive of a variety of health behaviors with an average multiple correlation between intention and PBC with behavior of $r = 0.52$ [30]. In other research, intentions have been shown to predict fruit and vegetable consumption [31] and participation in physical activity [32] in a college population. While sufficient improvements in intentions towards engaging in a behavior have been shown to promote behavioral change [33], future studies are necessary to determine if the observed improvements in determinants of behavior found in this study would result in improvements of actual behaviors as well as promote long-term behavioral change.

There are several limitations in this study worth noting. First, the participants in the study were self-selected, which may have resulted in a bias toward students with stronger interests in energy balance and perhaps a greater readiness for change in diet and physical activity behaviors. Moreover, for those students with strong intentions or very positive attitudes at baseline, the study may have failed to capture improvements in intentions and attitude due to the limitations of the self-perception instrument. Time may have also been a confounding factor in our study, as the students in the experimental and control groups completed pre and post assessments during different academic periods. Consequently, students in each group may have been subject to different environmental influences of behavioral change. Finally, the relatively short duration of the course may have limited the influence of the applications of behavioral theories in promoting change in determinants of behavior.

Effective interventions are needed in a college population to promote healthy diet and physical activity behaviors and support weight maintenance.

A college-level, energy balance course, designed and developed from a framework of behavioral theory, can be an effective tool in promoting increases in energy balance knowledge and improvements in attitude and PBC toward eating a healthy diet in a college population. This study suggests that the use of a science-based curriculum and engaging students in experiential learning through interactive activities can support a deeper understanding of energy balance concepts and promote improvements in energy balance knowledge. This study also suggests that the use of select applications of behavioral theory including peer and professional interviews, interactive activities, diet and physical activity recalls, diet and energy balance analysis and goal-setting activities can support improvements in attitude and PBC towards eating a healthy diet. Further, these applications of behavioral theory were perceived by most students to effectively influence their motivation/ability to eat a healthy diet and/or meet physical activity recommendations. These novel findings could play an important role in the future design and development of effective interventions in a college population for the promotion of behavioral change in energy balance behaviors.

Funding

This research was supported by a USDA HATCH Project VT-H01212 grant.

Acknowledgements

The authors thank Alan Howard, Statistical Consulting Services, UVM, for his assistance in the statistical analysis of the data.

References

1. Nelson MC, Story M, Larson NI, Neumark-Sztainer D, Lytle LA (2008) Emerging adulthood and college-aged youth: an overlooked age for weight-related behavior change. Obesity 16: 2205-2211.
2. Levitsky DA, Halbmaier CA, Mrdjenovic G (2004) The freshman weight gain: a model for the study of the epidemic of obesity. Int J Relat Metab Disord 28: 1435-1442.
3. Wengreen HJ, Moncur C (2009) Change in diet, physical activity, and body weight among young-adults during the transition from high school to college. Nutr J 8: 32-39.
4. Strong KA, Parks SL, Anderson E, Winett R, Davy BM (2008) Weight gain prevention: identifying theory-based targets for health behavior change in young adults. J Am Diet Assoc 108: 1708-1715.
5. Jackson EM, Howton A (2008) Increasing walking in college students using a pedometer intervention: differences according to body mass index. J Am Coll Health 57: 159-164.
6. Pawlak R, Cerutti CS, Quinton R (2009) Taking an undergraduate nutrition course results in favorable attitudes toward a healthful diet and improved intake of several key nutrients. Family and Consumer Sciences Research Journal 38: 3-10.
7. Wardle J, Parmenter K, Waller J (2000) Nutrition knowledge and food intake. Appetite 34: 269-275.
8. Poddar KH, Hosig KW, Anderson ES, Nikols-Richardson SM, DunCan SE (2010) Web-based nutrition education intervention improves self-efficacy and self-regulation related to increased dairy intake in college students. Journal of the American Dietetic Association Elsevier Inc 110: 1723-1727.
9. Kolb DA (1984) The Process of Experiential Learning. In Experiential Learning Experience as the Source of Learning and Development Englewood Cliffs NJ Prentice Hall Inc 20-38.
10. Franko DL, Cousineau TM, Trant M, Green TC, Rancourt D (2008) Motivation, self-efficacy, physical activity and nutrition in college students: randomized controlled trial of an internet-based education program. Prev Med 47: 369-377.
11. Karen G, Barbara RK (2005) Theory at a glance: A guide for health promotion practice. US Department of Health and Human Services National Institutes of Health National Cancer Institute.
12. Contento IR (2011) Nutrition education: Linking research, theory, and practice, Second Edition. Sudbury MA Jones and Bartlett Publishers.
13. Ajzen I (1991) The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes 50: 179-211.
14. Nordrehaug Astrom A, Rise J (2001) Young adults' intention to eat healthy food: extending the theory of planned behavior. Psychology and Health 16: 223-237.
15. Rhodes RE, Courneya KS (2003) Investigating multiple components of attitude, subjective norm, and perceived control: an examination of the theory of planned behaviour in the exercise domain. Br J Soc Psychol 42: 129-146.
16. Bandura A (1986) Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs NJ Prentice Hall Inc.
17. Bandura A (1999) Social cognitive theory : an agentic perspective. Asian Journal of Social Psychology 2: 21-41.
18. Bandura A (1989) Human agency in social cognitive theory. Am Psychol 44: 1175-1184.
19. Bandura A (2004) Health promotion by social cognitive means. Health Educ Behav 31: 143-164.
20. Bloom BS, Krathwohl DR (1956) Taxonomy of educational objectives: The classification of educational goals. Handbook 1: Cognitive domain. New York NY David McKay.
21. Notar CE, Zuelke DC, Wilson JD, Yunker BD (2004) The table of specifications: insuring accountability in teacher made tests. Journal of Instructional Psychology 31: 115-129.
22. Kitao SK, Kitao K (1999) Essentials of English Language Testing. Tokyo Japan Eichosha Co.
23. Ajzen I (2006) Constructing a TpB Questionnaire: Conceptual and Methodological Considerations.
24. Cohen NL, Carbone ET, Beffa-Negrini PA (2011) The design, implementation, and evaluation of online credit nutrition courses: a systematic review. Journal of Nutrition Education and Behavior Elsevier Inc 43: 76-86.
25. Buckley KM (2003) Evaluation of classroom-based, web-enhanced and web-based distance learning nutrition courses for undergraduate nursing. Journal of Nursing Education 42: 367-370.
26. Cousineau TM, Franko DL, Ciccazzo M, Goldstein M, Rosenthal E (2006) Web-based nutrition education for college students: is it feasible?. Eval Program Plann 29: 23–33.

27. Barbara M, Yukie T, Robert M, Marianne B, Karla J (2009) Evaluation of evidence-based practices in online learning: a meta-analysis and review of online learning studies. Office of Planning Evaluation and Policy Development Policy and Program Studies Service US Department of Education.
28. Matvienko O, Lewis DS, Schafer E (2001) A college nutrition science course as an intervention to prevent weight gain in female college freshmen. J Nutr Edu 33: 95-101.
29. Morris LM, Merrill RM (2004) Use of the dietary analysis plus program in an introductory college nutrition class. J Nutr Educ Behav 36: 213-214.
30. Armitage CJ, Conner M (2001) Efficacy of the Theory of Planned Behaviour: a meta-analytic review. Br J Soc Psychol 40: 471-499.
31. Blanchard CM, Kupperman J, Sparling PB, Nehl E, Rhodes RE, et al. (2009) Do ethnicity and gender matter when using the theory of planned behavior to understand fruit and vegetable consumption?. Appetite 52: 15-20.
32. Dzewaltowski DA, Noble JM, Shaw JM (1990) Physical activity participation: social cognitive theory versus the theories of reasoned action and planned behavior. Journal of Sport and Exercise Psychology 12: 388-405.
33. Webb TL, Sheeran P (2006) Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. Psychol bull 132: 249-268.