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Abstract

Objective: While colleges have implemented brief, tailored interventions for health-risk areas such as alcohol prevention, theoretically-guided digital learning offerings for weight gain prevention have lagged behind in programming and implementation. Thus, the objective was to design and usability test a weight gain prevention digital learning platform for college students with modules targeting key nutrition and physical activity behaviors.

Methods: Development occurred in iterative phases: formative research, descriptive normative data collection, prototype development, and usability testing. Formative research consisted of background work and survey administration to incoming and current freshmen. Prototype development was guided by theories of behavior change and cognitive processing, and consisted of brief assessment and feedback using written text, graphs, and videos. Iterative usability testing was conducted.

Results: Current freshmen reported eating more quick order meals per week than incoming freshman, but fewer high-fat snacks and fewer sugary beverages. Current freshmen reported more sedentary time than incoming freshmen. Based on iterative testing results, eight behavioral targets were established: breakfast, high-fat snacks, fried foods, sugary beverages, fruit/vegetables, physical activity, pizza intake, and sedentary behavior. Initial usability testers indicated the modules were easy to understand, held their attention, and were somewhat novel. Analysis of qualitative feedback revealed themes related to content, layout, structure and suggested refinements to the modules.

Conclusions: A gap exists for evidence-based obesity prevention programs targeted to adolescents as they transition into adulthood. Brief, tailored digital learning interventions show promise towards addressing key behavioral nutrition and physical activity targets among students during the transition to college.

Keywords

Obesity prevention, brief interventions, nutrition, physical activity, college students

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Approximately one-third of college students have overweight or obesity.¹ Among students attending 4-year colleges, weight gain averages between 3 to 4.3 kg during the first year, with further gains in subsequent years.^{2,3} The transition between adolescence and young adulthood, particularly for those students beginning college, is a vulnerable time period for weight gain as it is marked by changes in environment and food

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availability,⁴ declines in physical activity,⁵ and less healthful nutrition intake.⁶

College campuses are poised to launch weight gain prevention efforts given that nearly 50% of 18–19 year olds in the United States are enrolled at a postsecondary institution which support young adults during a developmental life stage primed for the establishment of lifelong health related behaviors.^{7,8} Yet, evidence-based weight gain prevention and treatment programming on college campuses has lagged behind interventions targeting substance use and high-risk sexual behaviors.⁹ A systematic review⁸ of diet, physical activity, and weight interventions in college students found significant effects in 18/29 of those with physical activity outcomes, 12/24 of those with dietary outcomes, and 4/12 of those with weight outcomes. While promising, the authors suggest that more work is needed to refine the strategies and delivery channels; characteristics of efficacious interventions were shorter-term (less than 12 weeks) and ones in which students received feedback on their behavior versus attending lectures. A gap remains regarding scalable, low-cost brief interventions targeting weight gain prevention on college campuses.

Interventions for health risk behaviors via college and university settings have been successful and serve as useful models for weight gain prevention programming. Online, interactive interventions addressing high risk health behaviors, such as tobacco, drug and alcohol use, and sexual violence have been adopted by colleges and universities.^{10,11} Programs that are alcohol-related include the Electronic Check-up to Go (e-CHUG)¹² and AlcoholEdu,¹³ which have each been implemented by more than 1100 colleges.^{11,14,15} These programs are brief, provide education, and deliver immediate, personalized feedback related to alcohol-use behaviors and risk factors. Self-guided computer-delivered interventions to reduce college drinking have demonstrated beneficial results,¹⁶ suggesting that similar programming that focuses on weight-related behaviors may offer colleges options to address an un-met need related to brief low-cost online programming to address weight gain.

Communications theories have been used to guide prevention campaigns on campuses.^{17–19} For example, “tailored” communication, or using a brief assessment to generate personalized messages, takes into consideration individual factors^{20,21} and has great potential for use in digital learning health promotion interventions.^{10,11} The use of tailoring in online programming has been shown to outperform non-tailored health behavior change interventions.^{20,22} In a meta-analytic review, interventions with tailoring on both theoretical factors, such as self-efficacy, and behavior were found to have an effect size of .092, suggesting a small but

positive effect.²² While this effect size may be small, estimates suggest that an energy gap of 100 kilocalories per day could prevent weight gain in the majority of the United States population.²³ A systematic review²⁴ found tailored communications effective for physical activity, fruit and vegetable consumption, fat, and other diet-related behaviors. Additionally, focusing on multiple target behaviors simultaneously was equally effective as a sole target.²⁵

Tailoring may enhance the personal relevance and salience of the message^{26,27} as well as motivation to process the message.²¹ Creating these conditions such that individuals can actively process or “elaborate” on messaging is consistent with the Elaboration Likelihood Model.^{21,27,28} Notably, self-efficacy appears to be an important factor in physical activity messaging and online programming among college students, with recommendations for including goal setting and other theoretically driven messaging to enhance this key behavioral precursor.^{29,30}

A number of online eating and body image interventions targeting college-aged populations have been described in the literature. Though the focus of these interventions varies significantly, covering topics such as nutrition,³¹ non-dieting,^{32,33} eating disorders,³⁴ and weight regulation,³⁵ the short-term effects are promising in increasing fruit and vegetable consumption, reducing stress, and preventing eating disorders among college students. However, none offer tailored feedback on both physical activity and nutrition goals or address behavior change principles including self-efficacy using communication science frameworks. To explore a more individualized approach, we designed a weight gain prevention program modeled after popular alcohol prevention programs. This digital learning weight gain prevention tool utilizes a theoretically driven approach to prompt self-assessment and provide brief, personalized feedback related to eight target behaviors.

Methods

The project occurred in four iterative phases: 1) formative research to identify key weight gain prevention behaviors; 2) descriptive normative data collection on weight gain prevention behaviors among incoming and current freshmen; 3) using theory to guide prototype development; and 4) usability testing. These iterative phases followed the consensus guidelines for developing health promotion interventions (Consensus Guidelines; See Table 1).³⁶ The setting was a mid-sized urban private university.

Table 1. Consensus guidelines for health promotion intervention development.³⁶

Development actions	Development phases	Overarching purpose
<ul style="list-style-type: none"> Plan the process Involve stakeholders Assemble a team of experts Review evidence 	Phase 1	<ul style="list-style-type: none"> Establish key weight gain prevention behaviors and target goals
<ul style="list-style-type: none"> Collect primary data to inform need Understand context and current landscape 	Phase 2	<ul style="list-style-type: none"> Establish a baseline for the target behaviors Examine the risk profiles of the target population Pilot test of measurement for the discrete, measurable behaviors
<ul style="list-style-type: none"> Apply and adapt existing theories Specify theory of action to design intervention 	Phase 3	<ul style="list-style-type: none"> Use existing theory to design the layout and content of a theoretically informed prototype
<ul style="list-style-type: none"> Undertake primary data collection to usability test the intervention Collect data to inform future implementation 	Phase 4	<ul style="list-style-type: none"> Examine the prototype for feasibility, acceptability of content and layout Describe how the format and content linked to the proposed communications science themes.
<ul style="list-style-type: none"> Further usability testing to refine and adapt the intervention Undertake primary data collection to test efficacy Collect data to inform future implementation 	Future Phases	<ul style="list-style-type: none"> Continue to refine and adapt the prototype Examine efficacy in real-world settings Include assessment of preferences, opinions of stakeholders (i.e., users and administrators) to inform future implementation facilitators and barriers

Phase 1: Formative research to identify key weight gain prevention behaviors

Purpose. The aim of this phase was to establish the weight gain prevention behaviors and target goals for each.

Methods. Examining a systematic review of diet, physical activity, and weight interventions in college students identified the variability in assessment of these outcomes.⁸ For example physical activity outcomes have included steps per day, days per week, minutes of moderate to vigorous physical activity, and fitness. Similarly, nutrition outcomes have been equally varied, and have included healthy eating indices, caloric intake, macronutrient composition. The variability in the outcomes potentially translates to confusion in how to establish easily describable goals to participants.

The study team reviewed the literature of weight related behaviors and targets. One study³⁷ identified 16 lifestyle, weight, and physical activity goals (e.g., eat breakfast every day). The strength of those goals were that they were concrete, which enabled ease of measurement and specific feedback. Another study³⁸ identified eight target behaviors (e.g., reduce sugary beverages). Based on this review, the study team

initially identified six key weight-related behaviors: eating breakfast, high-fat snack consumption (HFS), fast food consumption, drinking sugar sweetened beverages (SSB), fruit and vegetable consumption (FV), and physical activity (PA).^{37,38} These behaviors were selected based on their relationship to weight management, as well as the ease with which they could be used for self-assessment as they are brief and easily quantifiable to provide specific feedback on future behavioral recommendations. The study team also recognized that a long list of behaviors might be overwhelming and applied the communications science techniques to minimize cognitive load by keeping messaging simple and give the user control of the order of presentation of the behaviors (See Phase 3 below).

This list was presented to University stakeholders (i.e., associate dean of students directing the student engagement and outreach center, a registered dietitian and faculty member-in-residence, a former nutrition and PA coach at the university-based fitness facility, members of a university-based food task force) and refined based on their input.

Results. Based on stakeholder and content expert feedback, additional suggested behaviors were pizza intake and sedentary behavior. Given the nature of the urban campus, a shift from “fast” to “quick

order” food was also suggested. Another recommendation was to add an eating disorders screening with referrals to campus resources.

Lastly, building on input from stakeholders and content experts, we established the target goals for each behavior. The target selected for each behavior originated from current national guidelines or recommendations and evidence-based behaviors shown to promote weight maintenance in a diverse adult sample.³⁷ See Table 2.

Phase 2: Descriptive data collection of weight gain prevention behaviors

Purpose. As informed by the Consensus Guidelines for intervention planning,³⁶ primary data collection was conducted to understand behaviors within the university context. This served to establish a baseline for the target behaviors, examine the risk profiles of the target population, and enabled a pilot test of measurement for the discrete, measurable behaviors to be addressed in the intervention.

Methods. The survey protocol below was deemed Exempt by the IRB, as the survey data were not collected with identifiers. Eligibility was student status (i.e., current or incoming freshman). Current freshmen were recruited through flyers, student listservs, and faculty distribution to classes; incoming freshmen were recruited from a random sample provided by the university’s Office of Survey Research and Analysis. Current freshman participants received a free iTunes® song while incoming freshmen received a drawing entry for a \$20 university bookstore gift card.

Measures. Demographics were collected including age, race, sex, self-reported height and weight, and college year. Survey items related to each target behavior were selected from existing instruments, as follows:

1. Number of days breakfast was eaten over the past week was quantified by a single item from the National Longitudinal Study on Adolescent Health.³⁹

2. Number of HFS eaten per week was measured using 6 of 21 items from the PACE+⁶⁵ which assesses consumption of HFS in the last week, not including foods that could be considered a meal (e.g., hot dogs and hamburgers). PACE+ scores are significantly correlated with percentages of kilocalories from fat using 3-day food recall⁶⁵ and had adequate reliability in our samples ($\alpha = .56$ incoming freshmen; $\alpha = .51$ current freshmen).

3. Number of quick order meals (QOM) consumed per week. Frequency of ordering meals in the past week at a “quick order” restaurant was assessed with an item from the Food and Beverage Screener.⁶⁶ This

screener was validated against 24-hour food recalls and by test-retest reliability in an adolescent population.⁶⁶

4. Number of SSB consumed per week was assessed with the 19-item Beverage Intake Questionnaire (BEVQ).⁶⁷ We utilized the scoring methodology detailed by Hedrick et al. (2010) to determine the number of SSB consumed per day. This methodology is validated with 4-day food intake records,⁶⁷ and we had good reliability in our sample ($\alpha = .75$ for incoming freshmen; $\alpha = .81$ for current freshmen).

5. Number of servings of fruit and vegetables (FV) eaten per week was assessed using the National Cancer Institute Fruit and Vegetable Screener.⁶⁸ After surveying current freshmen, university stakeholders suggested that the survey was too long for incoming freshmen. Thus, for incoming freshmen, we abbreviated the measure to include general fruit and vegetable consumption rather than an itemized list. We adapted the scoring to reflect daily intake, with adequate reliability in our samples ($\alpha = .43$ current freshmen; $\alpha = .67$ incoming freshmen).

6 – 7. Minutes of PA/week and hours spent sitting/day were assessed using The International Physical Activity Questionnaire (IPAQ).⁶⁹ Weekly averages for moderate intensity PA and above and sedentary time were calculated. For data cleaning, those reporting >500 minutes of PA per day were excluded from analyses.

8. Pizza consumption was assessed using two items from the PACE+ questionnaire⁶⁵ (i.e., how often in the past week students ate pizza: 1) with cheese and vegetable toppings; 2) with meat toppings). Due to a clerical error, the pizza questions were not included in the incoming freshmen battery.

Results. Demographics were as follows: Of the current freshmen ($n = 103$; Mage = $18.54 \pm .61$ years; MBMI = 22.73 ± 3.76 kg/m²; 82% female) 19.05% had overweight (BMI between 25.00 and 29.99 kg/m²), 6.37% had obesity (BMI ≥ 30.00 kg/m²). For incoming freshman ($n = 116$; Mage = $18.15 \pm .47$ years; MBMI = 23.10 ± 4.3 kg/m²; 62% female) 15.92% and 6.32% had overweight and obesity, respectively.

Independent sample t-tests were conducted to calculate mean values and examine differences between incoming and current freshmen for each of the target behaviors (see Table 3). BMI ($N = 219$) was 23.04 ± 4.02 kg/m², with no statistically significant weight differences between current and incoming freshmen. For dietary behaviors, current freshmen reported eating more QOM per week than did incoming (3.26 vs. .71 meals/week), but fewer HFS (7.75 vs. 8.96 snacks/week) and fewer SSB (2.15 vs. 6.52 drinks/week) (all p 's < .001). Current freshmen reported more sedentary time (8.38 ± 4.95 hr/day) than did incoming ($5.51 \pm$

Table 2. Rationale for behavioral targets.

Behavior	Abbreviation	Original target (Phase 1)	Refined target (Phases 2 and 3)	Rationale
Days ate breakfast per week	Breakfast	7x per week	7x per week	Breakfast consumption is associated with lower body mass index (BMI), ³⁹ waist circumference, and fasting insulin. ⁴⁰ The Academy of Nutrition and Dietetics ⁴¹ and the American Academy of Pediatrics (AAP) ⁴² recommend youth consume breakfast daily, yet fewer than 25% of college students meet this recommendation. ⁴³ The AAP and the Academy of Nutrition and Dietetics recommends that breakfast be consumed daily. ^{41,42}
High-fat snacks per week	HFS	<2x/day	<2x per week	The American Heart Association recommends a low-fat diet to reduce risk of cardiovascular disease. ⁴⁴ However, 59-68% of college students report eating high-fat foods as snacks (e.g., cookies, chips). ⁴⁵ Findings from the literature ^{45,46} and our survey results indicated that high-fat snacks are eaten in excess by college students. The target for high-fat snacks was based on reviewing other studies with snack targets, one of which recommended to “avoid” high-fat snacks ³⁷ and the other was to target snacks to be <200 calories. ⁴⁷ Specific examples of snacks that were 200 calories or less were provided. The original target was framed as “smart snacking” of < 2 per day. Based on formative work, this target was refined to focus on “high fat” snacks of < 2/week.
Fast Food	Fried Foods QOM	Quick order meal: No more than 2x per week	Fast Food: ≤2x per week	Fast food intake is associated with a decreased likelihood of meeting nutritional recommendations, ⁴⁸ as these meals are often nutritionally poor and calorically dense. ^{46,49} About 80% of college students eat fast foods 1-3 times per week. ⁵⁰ This recommendation replaced “quick order foods” as that target may not have reflected healthier options available at quick order establishments. The fried foods target was based on recommendations for similar targets, one of

(continued)

Table 2. Continued.

Behavior	Abbreviation	Original target (Phase 1)	Refined target (Phases 2 and 3)	Rationale
				which recommended to “avoid” fast food ³⁷ and to aim for 5-10% of calories from saturated fat ^{44,51} (or 120-200 calories out of a 2000 calorie/day diet). Given the brief nature of the intervention and the difficulty of providing calorie-based targets, we operationalized this target as fried foods consumed no more than 2 times per week.
Sugary beverages per day	SSB	<2x per week	<2x per week	SSB is associated with weight gain in adolescent and adult populations. About 66% of college students report drinking one SSB daily, adding on average 543 kilocalories per day. ⁵² This recommendation was based on results from the student surveys (i.e., freshmen drank approximately four fewer sugary beverages than incoming students) and the recommendations of national organizations (e.g., AAP ⁵³ and the Centers for Disease Control and Prevention ⁵⁴).
Servings of fruit and vegetables per day	FV	At least 5 per day	At least 5 per day	In addition to providing vitamins and nutrients to prevent disease, increasing FV intake may promote satiety and weight maintenance due to high water and/or fiber content. ⁵⁵ However, fewer than 4% of college students eat five or more FV per day. ¹ Although the dietary guidelines for Americans describe a healthy diet as one that includes both fruits and vegetables, ⁵¹ it was important to have a specific target in order to provide feedback. The recommendation of five-a-day was derived from The US Department of Agriculture. ⁵⁶
Minutes of moderate and vigorous activity per week	PA	150 minutes per week	150 minutes per week	PA is shown to help adolescents and adults maintain weight, with recommendations of 60 minutes per day for adolescents and 150 minutes per week for adults by the Physical Activity Guidelines Committee. ⁵⁷ Activity declines by 24% during the transition from high school to college. ⁵

(continued)

Table 2. Continued.

Behavior	Abbreviation	Original target (Phase 1)	Refined target (Phases 2 and 3)	Rationale
				This goal is based on the Physical Activity Guidelines for Americans ⁵⁷ and recommendations by the American Heart Association ⁵⁸ to prevent heart disease and promote cardiovascular health. ⁵⁸
Hours spent sitting per day	Sedentary	<6 hrs per day	<6 hrs per day + breaks	College students sit about 6 hours (range = 2.43–11.09)/day. ⁵⁹ Sitting > 6 hours per day is associated with greater mortality risk. ⁶⁰ Current recommendations are to reduce sitting time by 3–6 hours per day. ⁶¹ Based on these limited guidelines we decided it was important to have a specific target and opted for sitting less than 6 hours/day.
Number of times ate pizza in past week	Pizza	No more than 2 slices/sitting”	No more than 2 slices on < 3 days per week	While no recommendations issued by national organizations exist to reduce pizza consumption, studies have shown that pizza consumption on any given day was associated with 230–385 more calories per day. ^{62,63} Given that 13–26% of young adults consume pizza on any given day, ^{62,64} we included this as a target. Based on intake patterns that students eat on average 3 slices per sitting, ^{62,64} the focus for a recommendation was based on reducing saturated fat intake by about 200 calories (or 10% of a 2000 calorie/day diet). This equated to about 1 fewer slice of pizza or consuming no more than two slices of pizza per sitting. Recommendations for healthier pizza options were included.

3.47 hr/day) ($p=.05$). Less than half (45.9%) of the current freshmen met the physical activity guidelines (≥ 150 minutes per week), while the majority of incoming freshmen did (81.8%, $p<.001$)

Phase 3: Prototype development and theoretical framework

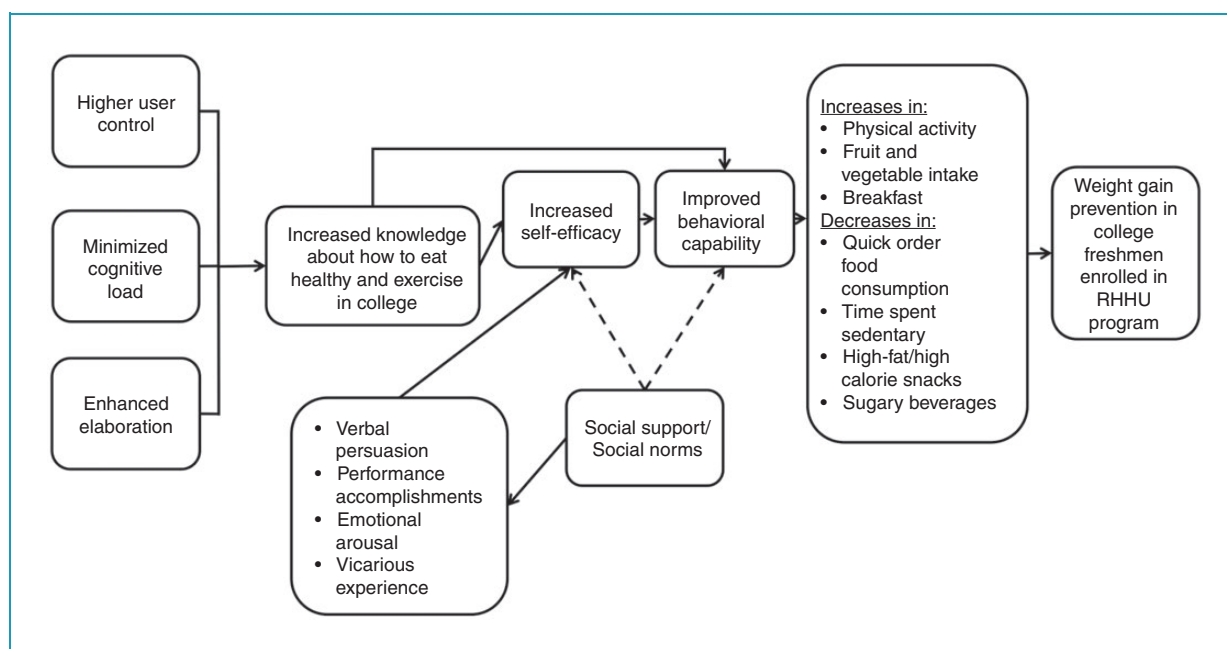
Purpose. The aim of this phase was to apply existing theory to design a theoretically informed prototype. The prototype was conceptualized after alcohol prevention programs like e-Chug,¹² to provide a platform for

individual assessment and personalized feedback. It was designed to be brief (10–15 minutes), self-guided (i.e., not relying on a face-to-face encounter), and to be completed once or in multiple increments to track one’s progress over time.

Methods. Prototype development was guided by three theories of how individuals process information and change behaviors: Elaboration Likelihood Model (ELM),^{28,70} Cognitive Load Theory (CLT),⁷¹ and Social Cognitive Theory (SCT).⁷² See Figure 1. These theories were selected based on their use in previous research.^{73,74} Members of the study team who were

Table 3. Demographic and behavioral information ($N = 219$).

	Incoming Freshman			Current Freshman			<i>p</i> Value
	<i>N</i>	Mean	SD	<i>N</i>	Mean	SD	
Age	116	18.15	.47	103	18.54	.61	<.001
BMI	92	23.10	4.30	103	22.73	3.76	.29
Days ate breakfast per week	87	5.61	1.92	91	5.03	1.83	.44
High-fat snacks per week	87	7.75	5.24	73	8.96	5.93	.52
Quick order meals per week	89	.71	.77	93	3.26	1.33	<.001
Sugary beverages per day	76	6.52	6.51	68	2.15	2.52	<.001
Servings of fruit and vegetables per day	116	3.10	3.35	85	1.80	1.04	<.001
Minutes of moderate and vigorous activity per week	44	317.70	165.99	61	170.25	113.55	<.001
Hours spent sitting per day	75	5.51	3.47	44	8.38	4.95	.05
Number of times ate pizza in past week (PACE)	<i>Not assessed</i>			73	2.60	2.99	
	<i>N</i>	%	<i>N</i>	%	<i>p</i> Value		
Race							
White	71	78.00	65	77.40			
Non-white	20	22.00	19	22.60	.71		
Meeting physical activity guidelines ($n = 105$)	36	81.82	28	45.90	<.001		

**Figure 1.** Conceptual framework.Legend: Adapted from Turner-McGrievy.⁷³

applying these theories to the prototype development were content experts in weight management, physical activity promotion, curriculum development, and design of on-line learning. The study team also consisted of both undergraduate and graduate students who served as proxy stakeholders.

ELM Theory Overview. According to the ELM, individuals are more likely to retain and apply information if they believe that it is personally relevant to them.⁷⁵ Methods of persuasion act through either the central route (i.e., user is actively engaged in thinking about and assessing the message) or the peripheral route (i.e., user is motivated by a message due to the reputability, source, or factor other than the specific content).²⁸

Application of the ELM to program design. Applying the ELM as a guide, the digital learning weight gain prevention tool included a self-assessment and personalized feedback. Tailored feedback was based on participants' current behaviors in comparison to the target (i.e., normative feedback) and reported self-efficacy in achieving the targets. See Figure 2 for example branching logic for delivery of feedback. Graphs displayed participants' reported behaviors compared with the recommendations. See Figure 3 for sample screen shots of workflows for PA. To foster central route processing, the program prompted interactivity such that students could perform a self-assessment and receive immediate feedback on their behavior in text and graphical depictions. The content was written specifically for college students, with examples, tips, and storylines relevant to them (e.g., taking a study break

and going for a walk, eating breakfast before an exam). To enhance the peripheral route persuasion, the information source was varied. In one module, the school mascot suggested the student drink water instead of a sugary beverage. In another, the source of the recommendation was clearly labeled as a reputable one (e.g., "You've been active for 150 minutes this week, which is the recommended amount from the US Department of Health and Human Services").

CLT Theory Overview. According to CLT, individuals retain more information when less effort is required to access the information and when they can control the pace of delivery of the information.^{76,77}

Application of the CLT to program design. Based on this theory, the material was presented in multiple formats (video, graphs, and text) with attention toward avoiding redundancy. For example, normative behavior feedback was presented in text with complementary visuals. These screens did not include any audio. Videos to engage learners were presented separately, allowing students to focus on the learning content. To mitigate a concern that users would feel overwhelmed with the number of target behaviors, the program was designed so they could control the pace and order of material. To address concern that messaging focusing on multiple behaviors may include tailoring that is too elaborate or complicated²⁵ (thus increasing cognitive load), the messaging was kept simple. Information was also streamlined so participants could choose to receive additional tips only if they chose to do so. Text covered brief feedback relative to the normative

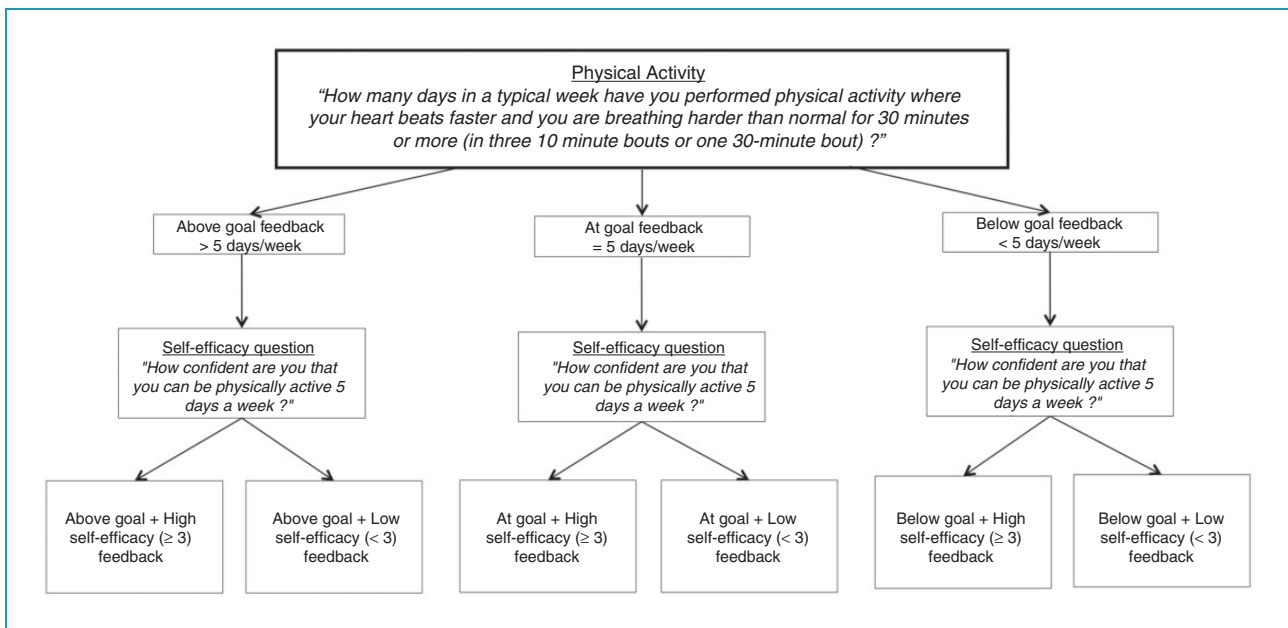


Figure 2. Branching logic example for tailored feedback messages.

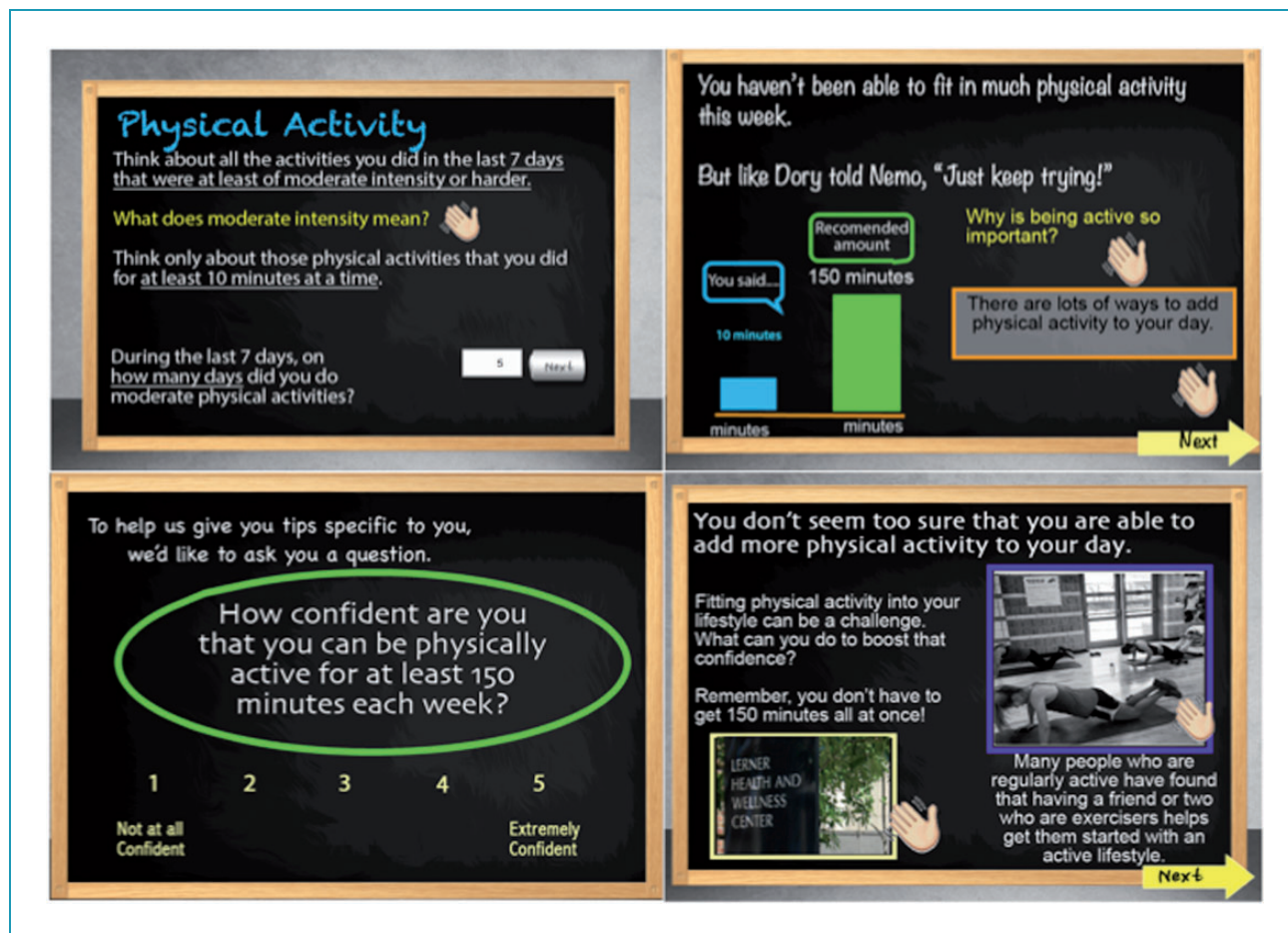


Figure 3. Screenshot of physical activity modules with assessment and behavioral feedback and self-efficacy feedback.

target and strategies to enhance self-efficacy as described below.

SCT Theory Overview. SCT highlights the importance of self-efficacy (one's confidence to make dietary changes and be physically active) in changing behavior.⁷² As depicted in Figure 1, we hypothesized that providing knowledge and factors to increase self-efficacy (e.g., verbal persuasion through tailored feedback, vicarious experience through watching peers model videos, performance accomplishments through self-assessment and feedback on target goals) would lead to increases in behavioral capability followed by behavior change. We further hypothesized that behavioral capability would be increased through the provision of specific knowledge about target behaviors.

Application of the SCT to program design. Thus, self-efficacy was used to tailor the written feedback (see Figure 2). Videos included peer-modeled behaviors to improve self-efficacy and target social norms, which also addresses another criticism of automatic computer tailoring: the lack of social context.⁷⁸ The goals for

each target behavior were explained to enhance this knowledge. Peer-led videos were used to provide a virtual social support community and role modeling of the skills needed to accomplish each behavior.

Phase 4: Usability testing

Purpose. The purpose of the usability testing phase is to test the intervention for feasibility, acceptability of content and layout, and briefly describe how the format and content linked to the proposed communications science themes.

Methods. The usability testing was IRB approved via expedited review. A waiver of documentation of consent was obtained for confidentiality purposes. Participants were recruited via departmental listservs and classroom announcements. Eligible participants were matriculating college freshmen, high school seniors, or current college students. This range was included to capture a variety of perspectives. Exclusion criteria included inability to fluently read English or provide written or verbal responses to

queries. Participants received a \$5 Amazon gift card for completion of each module. Testing occurred individually and lasted between 30-60 minutes. Using a post-test design, each participant tested one or two of the eight modules selected at random, ensuring all modules were tested at least 2 times prior to usability testing completion.

Following a brief orientation and overview of the testing purpose, participants completed a self-assessment for each module. This self-assessment included a reporting of their current behavior and perceived self-efficacy for reaching each behavioral target using a 1-5 likert scale. Both the participant's behavior and self-efficacy were used to provide graphical and written tailored feedback. The synchronous tailored message was based on participant's individual self-efficacy and normative behavior for reaching the target (See Figure 2 for the branching logic).

As participants viewed the modules, they were asked to verbalize their reactions and likes/dislikes related to graphics, message content, and page layout. This was recorded along with note taking by the research assistant. Following this review, participants completed a brief usability questionnaire.

Phase 4: Usability testing results. Participants ($n=21$; $Age=20.1$ years; $MBMI=23.4$ kg/m²; 57% female; 33.4% lowerclassmen; 66.7% upperclassmen) viewed the modules and provided feedback as noted above. Target behavior prevalence is listed in Table 4. The qualitative feedback was transcribed and categorized by two members of the study team. The following themes emerged:

1. **Presentation order.** Students reacted positively to the order of presentation. They liked that information was presented with assessment first, followed by graphical feedback, tips, and videos.
2. **Tips.** Students liked receiving specific tips about sharing pizza with friends, healthy alternatives, and planning meals ahead. They wanted more tips on ways to be active and modify sedentary behaviors, as well as finding healthy snacks on a budget.
3. **Campus-specific information.** Students wanted specific city and school-based tips and liked having the school mascot or campus landmarks in the video.
4. **Rationale for target behavior.** Students wanted more information and references regarding the sources for the target behaviors.
5. **Target goal.** For three of the target behaviors (i.e., PA, sedentary behavior, and pizza), some participants had difficulty quantifying them, and stated that the goals seemed "unachievable" or "unrealistic." Students often reported difficulty turning down "free food at university events." Some students reported performing exclusively vigorous activity when exercising, although only moderate PA was assessed in the program.
6. **"Too wordy."** Students felt there was too much information on the slides, and the slides should "look cleaner."
7. **Videos.** Feedback for videos was mixed. Some felt the videos provided "good tips" while others felt the videos were "cheesy."
8. **Layout.** Figure 3 shows the layout for the modules. Layout feedback was mixed. Some students liked the chalkboard design, while others found it to be

Table 4. Target behavior prevalence from usability testing sample.

	Current reported behavior			Self-efficacy (1-5 scale)		
	<i>N</i>	Mean	SD	<i>N</i>	Mean	SD
# days ate breakfast	5	4.8	2.28	5	4.8	.45
# times ate high-fat snacks per week	5	2.4	.89	5	2.6	1.82
# fruit and vegetables eaten per day	5	4.2	1.79	5	4.0	1.23
# slices of pizza per sitting	5	1.8	.84	5	4.0	1.23
# times ate fried foods per week	5	3.2	1.92	5	4.0	1.23
# sugary drinks per week	5	8.0	10.37	5	4.2	1.30
# minutes of physical activity	5	208.0	160.80	5	4.4	.55
# hours spent sedentary	6	8.3	2.73	6	3.8	1.64

“juvenile.” Most students liked the graphical feedback, while a few felt it was “not effective.” Students liked the interactive options provided on each screen.

9. **Theoretical feedback.** Students found the material and the presentation relatable (ELM). Students also commented on the “source” of the messaging (ELM). Having the school mascot as a “source” resonated for them; for modules where the national guideline or organization was not listed with the target goal, students wanted more specifics about that type of source. Most students remarked they liked the interactivity and the graphical feedback of their self-comparison to the target (ELM). Students also noted the feedback was easy to understand (CLM) and different students remarked on the variety of the presentations (e.g., graphs, videos).

Discussion

Targeting students as they transition to college addresses a life stage change⁴ that is associated with nutrition and physical activity behaviors.^{5,6} Surveys of incoming and current students helped to confirm the measurable behaviors and the need for intervention. The dietary behaviors of the participants in this study underscore the need for easily accessible programming to address healthy eating behaviors. For example, participants reported consuming less than 5 servings of FV per day (3.10 incoming and 1.80 current) and consuming a significant amount of SSB per day (6.52 incoming; 2.15 current). Also, our results show that less than half of the current freshmen met the recommended amount of PA while over 80% of the incoming freshmen met current recommendations. These results indicate the potential benefits of delivering a brief self-assessment driven intervention to prevent the decline in healthy eating and PA behaviors regardless of initial weight status.

Information obtained during Phase 2 was useful for selecting the behaviors for the digital learning weight gain prevention feedback tool. By synthesizing information from literature reviews, leaders on campus, and content experts, the eight behaviors were selected as important and viable targets. Critical to this phase was the selection of target goals for each behavior, which were based on existing current national guidelines or recommendations and a weight maintenance program for adults.³⁷ One challenge included finding brief, measurable, and achievable targets linked to a reputable national or international organization. For example, pizza consumption and sedentary behavior were emerging as important targets, yet to date, there are few specific measurable national or international guidelines. For sedentary behavior, the target was

based both on participant feedback and emerging information. Additional targets may be important for future consideration (i.e., sleep, stress) as those also can intersect with important cardiometabolic health targets^{79,80} and healthy eating and activity.^{81,82}

Usability testing was helpful to understand students' perceptions of the topics, videos, and feedback. This project was designed as a proof-of-concept to inform messaging and behavioral targets⁸³ and to determine necessity of further testing and implementation. Qualitative feedback from the target audience revealed eight themes. Some themes reflected the theoretical framework. For example, many students liked the order of the materials presented, minimizing cognitive load, and others liked the graphical feedback showing their behavior in comparison to the target. Self-efficacy is a key precursor for both physical activity and dietary change (SCT),⁸⁴ therefore, using one's confidence as the basis for the tailored messages was grounded in this perspective. Future pre-post designs to assess changes in these theoretical constructs will provide further data regarding the value of using these theories in program design.

Feedback from students also informed plans for future modifications to the program (See Table 1), including simplifying wording and reducing the amount of on-screen text; adding more tips; and refining pizza, snacks, and sedentary behavior targets. Future refinements will include: change “no more than 2 slices/sitting” to “no more than 2 slices on ≤ 3 days per week” for pizza; “ < 6 hours a day” to “ < 6 hours a day, plus breaks” for sedentary behavior; and “no more than 2 per week” to “no more than 2 per day” for snacks. Participants also noted that only moderate-intensity activity was described in the physical activity module, and therefore vigorous activity will be covered. Students also liked the branded nature of the materials. Future versions can include the ability to provide a customizable platform with branding options for each campus including a selection of school colors and potential to incorporate static images of their mascot.

There are limitations of the current study. First, we recruited a convenience sample of students from one private university who may not be representative of students at other colleges. For example, students reported sitting between five and eight hours per day, which is lower than reported elsewhere.⁵⁹ Accounting for sedentary time may be subject to recall bias;⁸⁵ therefore, these reports of sitting time may be an under representation. Second, only students interested in research focused on preventing weight gain in college participated, which may represent a selection bias. Only a small portion of the incoming and current freshman completed the survey and most were female and

white; therefore, results yielded from the formative surveys should be interpreted cautiously. Third, although helpful in generating a prototype version of the program, the software platform was limited in functionality and layout options, perhaps contributing to some of the feedback received. The usability testing was done in a controlled setting; therefore, it does not approximate what use would be like in a home or dormitory setting. The sample who completed the usability testing were similar in BMI but older. The age increase is likely related to the decision to include older students to learn from a range of undergraduates to inform the research team as to whether the program depicted an accurate and realistic reflection of the undergraduate campus culture.

Conclusions

This study involved the formative work to design a digital learning weight-gain prevention self-assessment and feedback tool targeting young adults as they transition from high school to college. Prevention programs that are brief, easy-to-use and self-paced targeting this transition period are needed, especially as students develop their own health patterns and behaviors. This study adds to the literature on low-cost online weight gain prevention programming for college students as it addresses usability of the interface, relevance to the target population and capability of delivering a self-assessment and feedback tool for weight gain prevention through a digital channel. Colleges and universities are potential avenues for helping students foster health and well-being by providing opportunities on-campus for easily accessible healthier options.⁸⁶ Mandating digital learning programming focused on tailored messaging about healthy eating and physical activity, similar to alcohol use programs required by over 500 colleges and universities, may provide a first step towards improving overall student health and well-being.

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