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Using Avatars to Model Weight Loss Behaviors: Participant Attitudes and Technology Development

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Abstract

Background:

Virtual reality and other avatar-based technologies are potential methods for demonstrating and modeling weight loss behaviors. This study examined avatar-based technology as a tool for modeling weight loss behaviors.

Methods:

This study consisted of two phases: (1) an online survey to obtain feedback about using avatars for modeling weight loss behaviors and (2) technology development and usability testing to create an avatar-based technology program for modeling weight loss behaviors.

Results:

Results of phase 1 (n = 128) revealed that interest was high, with 88.3% stating that they would participate in a program that used an avatar to help practice weight loss skills in a virtual environment. In phase 2, avatars and modules to model weight loss skills were developed. Eight women were recruited to participate in a 4-week usability test, with 100% reporting they would recommend the program and that it influenced their diet/exercise behavior. Most women (87.5%) indicated that the virtual models were helpful. After 4 weeks, average weight loss was 1.6 kg (standard deviation = 1.7).

Conclusions:

This investigation revealed a high level of interest in an avatar-based program, with formative work indicating promise. Given the high costs associated with *in vivo* exposure and practice, this study demonstrates the potential use of avatar-based technology as a tool for modeling weight loss behaviors.

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Abbreviations: (BMI) body mass index, (SD) standard deviation, (VR) virtual reality

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Introduction

More than two-thirds of adult Americans are overweight or obese.[1] The health and psychosocial benefits of weight loss are well documented.[2–4] Behavioral and cognitive principles guide most empirically supported weight loss interventions,[5] with patients being expected to practice behaviors (e.g., calorie monitoring) between sessions.[5–7] Self-monitoring is associated with successful weight loss outcomes, yet few individuals consistently practice these health behaviors.[8,9] To combat treatment barriers and reach larger and more diverse populations, researchers are using non-face-to-face methods, such as podcasts,[10] the Internet,[11,12] and automated voice response.[13]

Virtual reality (VR) and other avatar-based technologies can be used to create visual experiences that mirror real life.[14,15] Virtual reality has been utilized successfully to address clinical and health issues such as posttraumatic stress disorder,[16] addictions,[17–19] body image disturbance,[20] and binge eating disorder.[21] Participants are more likely to identify with a virtual entity (or avatar) resembling them compared with those who look dissimilar.[22,23] Avatar-based technology also has been used to promote and model physical activity.[24,25] For example, those who watched an avatar resembling themselves run on a treadmill reported exercising more on the following day compared with those who watched an avatar who resembled another.[25,26] There are two studies, to our knowledge, that have used VR for weight loss.[27,28] In one trial of 211 morbidly obese women, those assigned to a 6-week "experiential cognitive therapy" [group therapy sessions plus traditional VR (i.e., with eyewear and headset)] lost approximately 3.2 kg compared with a weight gain of 0.4 kg in the waiting list group at 6 weeks. Another trial compared the use of virtual group meetings to face-to-face for delivery of a 12-week weight loss program, finding comparable weight losses with each approach (3.9 kg for VR and 2.8 kg for face-to-face).[28]

Modeling and observational learning are important for behavior change;[29] observing a model can increase self-efficacy via processes such as performance accomplishments and vicarious experiences.[30] Virtual reality and other avatar-based technologies are tools that can be used to illustrate and model weight loss behaviors, because they provide a controllable, naturalistic environment that can be tailored to include features that are relevant for target weight-related behaviors;[8,31,32] they also may be particularly relevant for non-face-to-face treatment methods. However, gaps exist regarding the usability of an avatar-based program for the general population interested in losing weight. Thus, the purpose of the current study was to (1) assess initial interest in, and perceptions of, an avatar-based program for modeling weight loss behaviors and (2) develop and conduct a usability test on an avatar-based program for modeling weight loss behaviors.

Methods

Institutional review board approval was obtained. Phase 1 was an online survey to obtain initial feedback on an avatar-based program for modeling weight loss behaviors. Phase 2 consisted of avatar and module development along with usability testing. Only women were recruited for this initial trial due to both a resource allocation decision, as well as the sex-specific differences in body image in response to figure rating scales.[33,34]

Phase 1: Online Survey Research

Participants

Participants were recruited online via postings, as well as in-person announcements and flyer postings (online recruitment was not limited regionally). Recruitment messages specified participants must be overweight/obese and interested in losing weight. To access the online survey, women self-reported height and weight [body mass index (BMI) ≥ 25 was required]. Of the 153 women who started the survey, 128 participants completed it [mean age = 34.10 years, standard deviation (SD) = 13.01 years, range = 18–60 years; race = 57.0% white, 25.8% black, 10.2% Asian/Pacific Islander, 3.9% Hispanic/Latino, 3.1% other; mean BMI = 34.30 kg/m^2, SD = 8.15 kg/m^2].

Measures

Demographics: Participants provided information regarding their age, race, self-reported height and weight, and dieting

history (e.g., "In the past year, how many times have you started a weight loss program on your own that lasted for 3 days or less?")[35] over the past year.

Technology Use: Participants provided information related to their computer and video game use [e.g., "Do you play (or have you played) online role-playing games that use avatars (e.g., *World of Warcraft*, *The Sims*)?"], exposure to/interest in technology and VR [e.g., "How much do you enjoy using technology (for example, Internet, computer, cell phone, Kindle)?" and "Have you ever used VR?"].

Program Interest: Participants provided information about their interest in a VR weight loss program, perceptions of perceived helpfulness, suggestions for duration of sessions, and skills they would like to see modeled.

Phase 1 Results

Dieting History

More than two-thirds (71.9%) of participants had attempted to lose weight during the past year, with the average number of attempts lasting up to 3 days = 4 (SD = 8.60). Women reported most commonly using their own diet (46.1%) and exercise (37.5%) plans.

Technology Use

All participants accessed the Internet/email at least daily, and 90.6% enjoyed using technology most or all of the time; 32.0% played online games that used avatars. The majority of participants had never used VR (95.3%) or *Second Life* (98.4%).

Program Interest

Interest in an avatar-based program for modeling weight loss skills was high: 88.3% of participants reported they would participate in a program that used an avatar to help practice weight loss skills. Qualitative responses included "Seeing 'myself' exercising or eating correctly … will help me visualize myself following these examples," and "I would use the avatar because simulating a behavior can help reinforce positive choices."

A majority of participants (71.9%) believed such a program would be at least somewhat helpful and anticipated that the avatar-based program would yield strong effects [anticipated average weight loss of 3.4 kg (SD = 1.97 kg; range = 0.91–13.61 kg) during the first month of a VR program and 7.92 kg (SD = 3.88 kg; range = 1.36–27.22 kg) after 3 months].

Topics of Interest and Length of Sessions

Topics that are frequently covered in traditional behavioral weight control programs[6,36] were selected by three clinicians and provided to participants to indicate their interest as virtual module topics: exercise (80.5%), dealing with cravings (73.4%), portion control (72.7%), menu planning (71.1%), avoiding emotional eating (69.5%), mindful eating (65.6%), choosing and eating healthy foods (64.8%), eating in high-risk situations (58.6%), stimulus control (56.3%), navigating a grocery store (46.9%), and nutrition label reading (46.1%). The majority of participants (66.4%) indicated that the sessions should last 15–30 min (35.9%) or 30–45 min (30.5%).

Figure 1. Sample avatar.

Phase 2: Technology Development and Usability Testing

Avatar Development

Avatars varied in shape and size similar to traditional figure rating scales[33,37] and were available in three skin tones (**Figure 1**) based on feedback received during phase 1.

All programming was developed in-house and used the *Second Life* platform.[38] *Second Life*, is a three-dimensional virtual world platform that allows users to build and create objects, interact with a virtual environment, and connect with others. *Second Life* is considered to be the most popular of the virtual worlds.[39] The avatar body shapes were customized to reflect dimensions of obesity. This was accomplished by customizing the various body parts from a standard shape present in the inventory section of the *Second Life* platform.

Weight Loss Behavior Virtual Environment Module Development

Theory: The use of avatars as models for weight loss behaviors is based on social cognitive theory[40,41] and behavior change principles,[5,6,42] specifically, self-efficacy.[40,43] The modules were designed to address the three main sources of self-efficacy processes (**Figure 2**): (1) performance accomplishments are targeted via exposure to the avatar and self-instructed performance, (2) vicarious experiences are targeted via symbolic modeling by observing the virtual model, and (3) verbal persuasion is addressed via suggestion and instruction provided by dietitian-delivered voice-over description.[30]

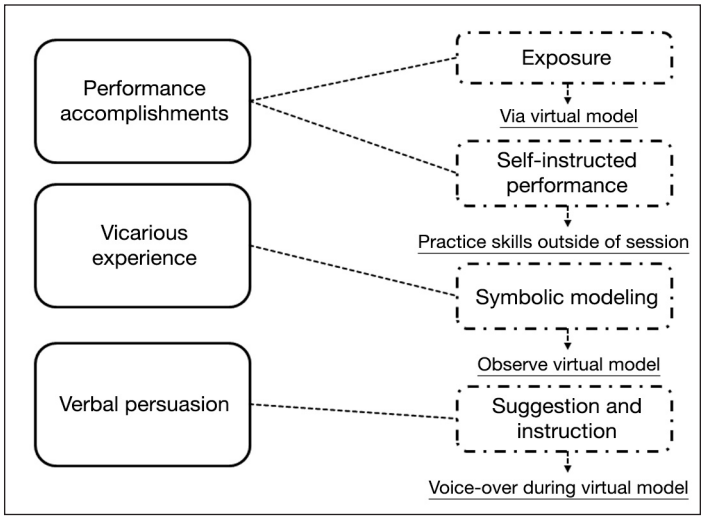

Figure 2. Model for addressing self-efficacy in avatar-based modules.

Target weight loss behaviors and content delivery: Topics were selected by three clinicians to address behaviors covered in traditional behavioral weight control programs[6,36] and included (1) navigating a supermarket and shopping for low-calorie items, (2) physical activity, (3) portion sizes, and (4) stimulus control. Session content was delivered prior to avatar modeling electronically via a standardized digital recording by a registered dietitian (topics were presented as they would be in face-to-face treatment).

Virtual Module Development: Four virtual environments were created (i.e., supermarket, home gym, dining room/kitchen, and living room) in which the avatar demonstrated healthy weight control behaviors (**Figures 3** and **4**) related to weekly session topics. Following content delivery, the simulation was shown (i.e., avatar modeling the skill with narration by dietitian). For example, for the physical activity module, this would involve having the avatar demonstrate walking on a treadmill at a moderate intensity.

Figure 3. Grocery store module.

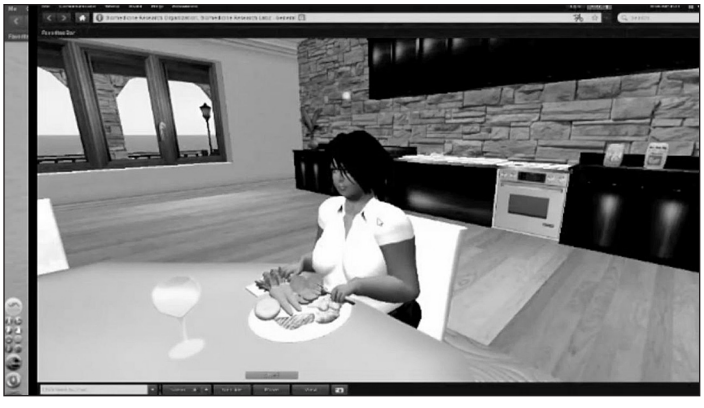

Figure 4. Portion control module.

Usability Testing

Usability testing incorporates two main components: (1) user satisfaction and preference and (2) objective measures.[44] For the purposes of this study, user satisfaction will include views on program usefulness for behavior change, and

preferences will include feedback about the avatar. Program objective measures will include weight loss and change in psychosocial measures.

Recruitment

Participants were recruited using similar methods as described for phase 1. Women completed a brief questionnaire online to determine eligibility (i.e., 18–65 years old, BMI of 25–40, no concurrent weight loss treatment, and no health contraindications). All participants received a physical exam prior to enrollment. Women accessed the online screening survey (46 started, 39 completed); of those, 26 were ineligible [outside BMI or age range (n = 12); health (n = 4); participating in another study/weight loss program (n = 5); disordered eating (n = 4); no longer interested (n = 1)]. Of the remaining 13 who were eligible, 5 could not participate because of scheduling issues or the clinic location.

Participants

Enrolled participants (n = 8; mean age = 44.13 years, SD = 10.56 years; mean weight = 93.80 kg, SD = 16.18 kg; mean BMI = 33.32, SD = 3.45; 62.5% black, 25% Caucasian, 12.5% Hispanic) reported accessing the Internet/email at least daily; all noted that they enjoyed using technology. Only one participant had used VR, and none had prior experience using an avatar-based technology program, including video games. Participants received a $5.00 gift card for each session they attended and a $10.00 gift card for completing post-treatment assessment.

Measures

Participants completed a series of questionnaires at baseline and immediately post-treatment. They also provided qualitative data.

Height and Weight: Height was taken using a stadiometer to the nearest one-fourth inch. Body weight was measured on a calibrated scale; BMI was calculated based on height and weight [BMI = weight (kg) / height^2 (m^2)].

Physical Activity Self-Efficacy: The five-item physical activity self-efficacy[43] assesses one's confidence to exercise in challenging situations (e.g., "when I am tired") using a five-point Likert scale ("not at all" to "extremely confident") and has demonstrated good internal consistency (0.76) and 1-week test–retest reliability (0.90).[43]

Weight Self-Efficacy: The weight self-efficacy[45] measures the perceived control over food-related behaviors and incorporates 20 different food-related situations [e.g., "I can resist eating when I am depressed (or down)"] rated on a nine-point Likert scale ("not confident" to "confident") and measured using the resulting total and five subscale scores: negative emotions, availability, social pressure, physical discomfort, and positive activities. Reliability for the total scale and subscales are adequate (alpha > 0.70).[45]

Goal Setting and Planning: Goal setting and planning[46] was measured using the exercise goal-setting scale and the exercise planning and scheduling scale. Each measure is 10 items and assesses the ways in which one plans, schedules, and sets goals for adopting daily physical activity (e.g., exercise goal-setting scale, "I tend to break more difficult exercise goals down into a series of smaller goals," and exercise planning and scheduling scale, "I never seem to have enough time to exercise") using a five-point Likert scale ("does not describe me at all" to "describes me completely"). Additionally, we adapted this measure to also assess goal setting and planning for nutrition and weight loss. This measure has good internal consistency (exercise goal-setting scale = 0.89; exercise planning and scheduling scale = 0.87).[46]

Consumer Satisfaction: Participants completed weekly exit interviews and a post-treatment survey that assessed the degree to which the program and its components (e.g., virtual avatar modeling, video content, handouts) were helpful. These formed the basis of the user satisfaction and preference components of usability and included questions such as "Would you recommend the program to others?" "How helpful did you find the handouts and virtual models to be?" and "How interested would you be in having the avatar, or virtual model, look exactly like you (for example, your face and hair)?"

Procedure

In order to tailor the virtual model appropriately, participants chose the shape and skin color of an avatar that best

represented them. This selection determined which avatar would be included in the video to be watched by the participant. Participants attended four in-person individual weekly sessions (~30 min each) to control for treatment exposure time and minimize divided attention. The avatar shape did not change over time. During sessions, participants received standardized content via video and handouts (~10 min), watched an avatar that looked like them model evidence-based weight loss behaviors (~2–3 min), and watched a skill builder review (i.e., session review and behavioral goals for the week; ~2–3 minutes). Participants were also weighed by a research assistant, given time to review handouts and ask questions, and scheduled for their next appointment. Additionally, the research assistant reviewed participant safety (i.e., checked weekly calorie records for any entries <1000) and asked about any adverse events that might have occurred in between sessions.

Participants were instructed on calorie monitoring during the first video module, and they were instructed to self-monitor via a paper record throughout the study. Suggested caloric targets were 1200–1500 kcal/day, with higher intakes recommended for those with a BMI ≥ 35 kg/m^2. Participants were encouraged to gradually increase their physical activity (goal = 210 min/week[7,47,48]). Starting goals were individualized depending on baseline physical activity. Specific weight loss goals were not specified beyond a general recommendation of losing approximately 1–2 pounds per week.

Phase 2 Results

Usability Testing

User Satisfaction: With regard to satisfaction, 100% would recommend the program to someone else, felt the program influenced their diet and exercise behavior, and agreed that the weekly dietitian videos were helpful (87.5% found the virtual avatar models helpful). Comments included "Looking and listening to the virtual model reinforces you, and having someone monitoring you is great," and "The virtual models reemphasize weight loss skills."

All participants reported that the program met or exceeded their expectations. One participant noted, "I didn't think that a virtual program would help with behavior modification, but it has." All participants indicated that the topics were relevant to their weight loss goals.

User Preferences: Avatar Feedback: Participants were mixed regarding their desire to have an avatar that looked exactly like them (i.e., using their own facial image): 37.5% not at all; 25.0% somewhat; 37.5% to a great extent. Participant comments included "If the avatar didn't look exactly like me, it would not discourage me from practicing the skills," and "I think it would allow me to imagine myself doing these things more easily." Three-quarters of participants were interested in an avatar that changed size/shape as they progressed through the program. Control of Avatar: More than half of participants were interested in a more interactive program (i.e., allowing the participant to control the avatar and make choices in the virtual environments).

Weight and Psychosocial Outcomes: After 4 weeks of treatment, participant attendance was 100%, and the average weight loss was 1.6 kg (SD = 1.7); $t(8) = 2.55$; $p < .05$. All but one participant completed the post-treatment online survey. Results of paired samples *t*-tests revealed a significant increase in participant confidence from baseline (mean = 15.86, SD = 5.55) to post-treatment (mean = 19.00, SD = 4.43) on the physical activity self-efficacy scale, $t(6) = -3.67$, $p = .01$. Changes in the weight self-efficacy total, exercise goal setting, and nutrition and weight goal setting and planning subscale scores were non-significant (i.e., $p > .05$). Change in participant scores on the exercise planning and schedule scale approached significance, $t(6) = -2.34$, $p = .06$ (baseline: mean = 25.71, SD = 11.88; post-treatment: mean = 31.71, SD = 11.29).

Discussion

Avatar-based technology offers options for weight loss interventions, including the incorporation of behavioral modeling, simulated practice, and exposure to potential high risk situations.[14,32] Survey data revealed high interest (88%) among women in an avatar-based program for modeling weight loss behaviors. This finding is important, as it shows that, even among those who have not used avatar-based technology frequently, there is a basic level of interest and

understanding of the potential for its use as a weight loss tool. This type of delivery via digital media has great dissemination potential for a variety of settings (e.g., physician offices, college campuses, private homes).

Formative data collected as part of the usability testing indicated initial promise for using an avatar-based program for modeling weight loss behaviors; this is in terms of interest as well as pre–post results (i.e., participant retention, weight loss, and self-efficacy enhancement). While there was no control group with which to compare the results, weight losses approximated those observed in traditional weight loss programs (an average of 0.4 kg/week[49]). However, these results should be interpreted with caution given the small sample comprised solely of women. Additionally, these changes cannot be solely attributed to avatar modeling alone; however, this study was designed to use avatar modeling as a potentially scalable tool for weight loss.

Retention in the usability testing portion of the technology development (phase 2) was excellent (100%), and results provide support for expansion of the program and further evaluation in a randomized controlled trial to assess the additive benefits of avatar modeling in gold standard treatment. Consistent with the proposed theoretical mechanisms, participants also experienced improvements in their physical activity self-efficacy. Future studies are needed to expand the length of the program with a specific focus on targeting other forms of self-efficacy.

Some have posited that the process of watching an avatar being immersed in real-life situations might increase participant engagement and possibly behavior change.[8] Using theory to develop and examine avatar-based virtual environments for illustrating and modeling weight loss behaviors provides the essential framework for enhancing existing efficacious treatments for the nation's most prevalent public health problem.[2,50] Avatar-based virtual environments provide a controllable, naturalistic environment that can be tailored to include theory-based features that are relevant for modeling target weight-related behaviors.[8,31,32] The current study demonstrated the potential for theoretical innovations around how avatar technology can be used to enhance weight loss treatment and practice. The program was designed around the theoretical principles of engaging participants to develop and establish new patterns through behavioral modeling,[32] particularly via targeting ways of improving self-efficacy (i.e., performance accomplishments, vicarious experiences, verbal persuasion[30]). Future programs should focus on these sources of self-efficacy as specific targets.

Conclusions

In conclusion, strong interest expressed by participants during the formative work, as well as by our usability participants, suggests that an avatar-based weight loss program is of interest to racially diverse overweight and obese women. Results also suggest that a technology-based program featuring avatar modeling can achieve weight losses comparable to traditional face-to-face treatments.[51] The benefits of using virtual self-models as an adjunct to gold-standard treatment[5,6] is an important area of future research. Interactive avatar use in virtual environments should also be explored, as this technology offers clinicians the opportunity to observe patients practicing behavioral weight loss skills, thus allowing for the provision of immediate feedback and problem solving (in person or remotely). Avatar-based platforms have the flexibility for a variety of modifications, including changing avatar size and shape to mimic participant changes, as well as personalization to real markers in a participant's environment (e.g., kitchen, living room). The combined use of an avatar for modeling skills and delivery of gold-standard content via digital recording may likely increase the dissemination potential and cost-effectiveness of a new generation of behavioral weight loss intervention.

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Gary D. Foster is on the scientific advisory boards for NutriSystem, ConAgra Foods, United Health Care Group, and Tate and Lyle.

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