

Engaging adolescents in a computer-based weight management program: avatars and virtual coaches could help

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ABSTRACT

Objective This research focuses on the potential ability of animated avatars (a digital representation of the user) and virtual agents (a digital representation of a coach, buddy, or teacher) to deliver computer-based interventions for adolescents' chronic weight management. An exploration of the acceptance and desire of teens to interact with avatars and virtual agents for self-management and behavioral modification was undertaken.

Materials and Methods The utilized approach was inspired by community-based participatory research. Data was collected from 2 phases: Phase 1) focus groups with teens, provider interviews, parent interviews; and Phase 2) mid-range prototype assessment by teens and providers.

Results Data from all stakeholder groups expressed great interest in avatars and virtual agents assisting self-management efforts. Adolescents felt the avatars and virtual agents could: 1) reinforce guidance and support, 2) fit within their lifestyle, and 3) help set future goals, particularly after witnessing the effect of their current behavior(s) on the projected physical appearance (external and internal organs) of avatars. Teens wanted 2 virtual characters: a virtual agent to act as a coach or teacher and an avatar (extension of themselves) to serve as a "buddy" for empathic support and guidance and as a surrogate for rewards. Preferred modalities for use include both mobile devices to accommodate access and desktop to accommodate preferences for maximum screen real estate to support virtualization of functions that are more contemplative and complex (e.g., goal setting). Adolescents expressed a desire for limited co-user access, which they could regulate. Data revealed certain barriers and facilitators that could affect adoption and use.

Discussion The current study extends the support of teens, parents, and providers for adding avatars or virtual agents to traditional computer-based interactions. Data supports the desire for a personal relationship with a virtual character in support of previous studies. The study provides a foundation for further work in the area of avatar-driven motivational interviewing.

Conclusions This study provides evidence supporting the use of avatars and virtual agents, designed using participatory approaches, to be included in the continuum of care. Increased probability of *engagement* and long-term *retention* of overweight, obese adolescent users and suggests expanding current chronic care models toward more comprehensive, socio-technical representations.

Keywords: avatars, adolescent overweight and obesity, consumer health informatics, human-centered computing, human centered design and evaluation methods, participatory design, virtual coaches, chronic disease self-management, weight management, computer-based health interventions

BACKGROUND AND SIGNIFICANCE

Data from 2011 to 2012 reports, 31.8% of youths were either overweight or obese (16.9% were obese) in the United States.¹ Currently, obesity related healthcare costs equate to approximately \$1429 more per person each year compared to persons of normal weight.² These costs will rise as today's children reach adulthood afflicted with long-standing diabetes, hypertension, polycystic ovaries, and sleep apnea. The complication rate for these diseases may reduce the life expectancy of today's youths by 15 years.³

Obesity is a global public health issue particularly for developed countries.

Intensive lifestyle changes can reduce the burden of obesity related illnesses (e.g., improved nutrition and physical exercise); however, the implementations of such recommendations among targeted children are not adequately addressed in disease management models or widely available from lack of human resources.

Supporting healthy behaviors and an active lifestyle for our overweight and obese youth is an effort that must flow between the individual [and/or] family to the healthcare system and to the community, as depicted in the Chronic Care Model. Unfortunately, psychosocial

issues of an overweight or obese parent or cultural norms for behaviors and body image may hamper home support. Additionally, medical curricula do not adequately address training in lifestyle modification or patient engagement.⁴ Medical care typically focuses on the diseases associated with obesity rather than preventing the antecedent overweight condition and provides only infrequent, periodic interaction.

Furthermore, current community- or school-based programs to address obesity are labor intensive, have limited capacity, and are often temporary.^{5,6} Therefore, reinforcement to the continuum of care represented by existing models of chronic care is necessary and needed for positive, long-term effects.

A primary obstacle in changing unhealthy habits is often finding the motivation to change one's lifestyle. Recent trends in healthcare and medicine toward preventive interventions has given rise to an effort to develop effective evidence-based health promotion interventions to help people *find* and *cultivate the intrinsic* motivation to change. Motivational design must also recognize that chronic condition management is all day, every day for these adolescents—thus it requires the right tools at the right time in the right place.⁷ The existing social models of the chronic care continuum do not depict a

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continuum of 24/7 reinforcement. A socio-technical chronic care continuum that uses appropriately designed technology with needed functions to address gaps in existing models may help us move closer toward 24/7 reinforcement for those that want to adopt healthy behaviors.

Appropriate (e.g., right functions and design) technology in consideration of the user group's mental model and emotional stage (particularly, regarding intrinsic motivation) is crucial to technology assuming a role in the continuum of chronic disease care. Research indicates that high dropout rates from a low level of engagement, limited motivational design, and technological constraints⁸ limit the long-term adoption and success of health computer-based interventions in affecting change. Fitness and nutrition apps are typically designed with adults as the end user; therefore, any design targeting adolescents with chronic disease(s) must consider their motivational preferences, context, challenges, and needs. Studies indicate that interactive gaming improves knowledge and self-efficacy of chronic disease management in children. The increased availability of video games, internet-based applications, and mobile apps increase accessibility to health interventions on the go and on-demand, anytime, anywhere.

Whereas computer-based interventions might be considered dehumanizing⁹ and lacking the empathy necessary for delivering computer-based intervention (CBI) content, when coupled with avatars or virtual agents there are advantages that might re-humanize the user's interaction with the intervention.¹⁰ This is due in part to their ability to use the same communication channels as human's innate communication channels (e.g., speech, body language, facial expressions) and to adapt to the user's internal states and preferences in real time.

It is important to note that avatars and virtual agents refer to two different concepts in computing and information sciences. An *avatar* refers to the graphical representation of the user (most often a human-like representation, or for children anthropomorphized animals) in some virtual environment: the user controls the avatar's actions or "tele-operates" the avatar to interact in the system, such as chatting with other users' respective avatars within the virtual environment (e.g., as in *Second Life*). In the current study, an avatar corresponds to the virtual representation of the teen in our system, a "virtual-self," whose visual representation and actions are in response to the teen's preferences and actions. A *virtual agent*, on the other hand, has anthropomorphic graphical (or robotic) representation coupled with autonomy—that is, the user does *not* control the actions of the agent since the virtual agent interacts with and adapts to the user as a separate entity. In this study, a virtual agent corresponds to an independent character that provides trusted health-related information and behaves socially (e.g., motivational material delivered by the virtual agent empathically).

Regarding the potential of avatars and virtual agents, we already know that:

- computer systems can act as social actors: people respond to computers in social ways,¹¹ at times developing personal relationships with artificial agents viewed as mentor, coach, companion or, friend;
- anthropomorphic agents can express empathy: the explosion of avatars, embodied conversational agents¹² and virtual humans¹³ (also referred to as intelligent virtual agents) has widened the possibility to model empathy computationally, by sensing and adapting in real-time to the user's emotions (e.g., via automatic facial expression recognition, via text processing) during the interaction¹⁴;

- synthetic speech has become quasi natural and provides inter-ventional access to low-literacy populations and technophobic individuals;
- patient-physician concordance can be increased: people respond to ethnicity in virtual agents and in humans. The same words mean different things based on the speaker, thus reception from a virtual agent of similar ethnicity may be improved; and
- natural language understanding enables spoken dialog: spoken dialogs conducted by virtual agents with semi-constrained natural language dialogs (rather than, or in addition to surveys and menus) can improve the avatar and virtual health agent (VHA) experience.^{10,15}

Therefore, it seems that the use of virtual agents and immersive video games for health makes sense considering the level of engagement of teens in immersive games and the huge deficit in medical resources to combat obesity. In fact, in the health and medical domain, specific terms are emerging, such as *medical avatars* and *virtual health agents* (VHA)^{10,16} to refer to avatars and virtual agents (respectively) "specialized" in medical and health applications. Research supports avatars' and virtual agents' capabilities to improve accessibility to information and lifestyle modification approaches, to be cost-effective in information delivery, to decrease barriers to access, to provide fun for the user,¹⁷ and to provide a motivating and educationally valuable learning experience.^{8,18,19} In addition, support exists for the use of avatars as a supplemental component of face-to-face weight-loss treatment programs, particularly among women. Because of the aforementioned support, the proposition underpinning this study is that the use of animated virtual agents and avatars can elevate CBIs targeting overweight and obese youths to their full potential by effectively improving users' engagement, accessibility, and ultimately users' health outcomes in a cost-effective program.

Although support exists, there remains a dearth of research in relevant domains, (e.g., computer science, information systems, and healthcare) to provide insight regarding the functions, design, context of use, and factors that influence user intention and acceptance of the virtual in healthcare, and ultimately the potential role of these technologies in health behavior modification. We can draw upon some recent studies in information systems literature of virtual worlds²⁰ that indicates that interaction and the perceived value of communication play pivotal roles in user acceptance and technology adoption. However, these findings do not provide specific understanding regarding the avatar or virtual agent's role (i.e., what is the focus/purpose of communication), how the user would like to interact with an avatar or virtual agent, or what contextual or environmental barriers may exist to use and adoption. Furthermore, studies in information systems and computer science do not often call upon the user to participate in the development process (of deploying avatars for purposes of health management) to better understand the intended users' context and mental model. In turning to the healthcare literature, there are few studies that investigate expanding avatars and virtual agents into changing patient behaviors; furthermore, the existing small-scale studies have produced mixed results.²¹ Given the current state of literature, it is understandable that researchers in various domains have called for further work regarding avatars and virtual environments.

OBJECTIVE

As few computer-based systems harness the power of animated virtual agents and avatars coupled with few studies on the matter, this study explores the potential for computer-based intervention involving

avatars and virtual agents for adolescent weight management. Our objectives are twofold: 1) providing effective motivational weight management for adolescents by addressing continuum of care “white spaces”, and 2) reducing the accessibility and engagement gap of computer-based interventions. Our study seeks to address the following research questions using a community-based approach to give adolescents, their parents, and their medical providers a voice in the potential role and context of avatars within a lifestyle modification program:

R1: What roles can avatars and virtual agents take in a CBI to facilitate superior self-care for adolescent overweight and obesity as part of a continuum of managed care?

R2: What are the opportune contexts for the use of avatars and virtual agents to facilitate healthy behaviors for overweight adolescents?

R3: What are the potential barriers to overweight adolescents in using avatar and virtual agent technology to facilitate self-management?

R4: What are the potential reinforcements to overweight adolescents in using avatar and virtual agent technology to facilitate self-management?

Answers to these questions are relevant to medicine and health services as they consider the role of technology in the continuum of care. In addition, these questions are also relevant to not only to computing and information sciences researchers interested in health technology application. Results may influence what technical methods in addition to software design and development are investigated in the future in order to provide the maximum impact from medical avatars and VHAs.

MATERIALS AND METHODS

This study was inspired by a community-based participatory research approach to exploring design and human computer interaction. This approach focuses on users, tasks, social context, and their support system; measures usability empirically and designs iteratively, whereby a product is designed, evaluated, and modified with real users and their supporting network in repeated quick iterations.

This approach engineers strategies to incorporate ease of use into the total customer experience with products and information technology (IT), applied specifically to healthcare IT systems.^{22–24} Our specific approach is a four-dimensional experience framework that assesses:

1. usability (human–computer interaction elements are often under tested) of prototyped designs,
2. practicality (utilitarian value),
3. hedonic/empathetic feelings and emotions derived from the experience, and
4. sociability (given adolescents’ attraction to avatars) of the user experience.^{25,26}

The study, conducted in three phases, encompassed 1) analysis of overweight adolescents’ needs, technical infrastructure, human–computer interaction preferences, and social contexts of use; 2) design, prototyping, usability; and 3) final development and proof-of-concept field evaluation. This paper focuses on Phases 1 and 2, which consisted of a qualitative, multi-perspective, multi-method, exploratory research study. Methods and protocols identified key goals, functionality, and design requirements while determining potential barriers and facilitators to usage of technology aids in assisting overweight and obese adolescents with their self-management. Data

collection techniques included: a) 10 user-driven design focus groups with adolescents participating in 2 existing self-management programs; b) 15 semi-structured interviews with parents of overweight and obese children participating in self-help programs; and c) 6 semi-structured interviews with pediatric physicians. Five broad application areas evolved: social networking, motivation, cooking, physical activity management, and food management. Additionally, design ideas included the potential use of avatars.

Phase 2 activities began with iterative prototyping and usability analysis based on the results of Phase 1. We recruited 70 adolescents from Camp Jump Start (<http://www.campjumpstart.com/>), a recognized adolescent weight loss and healthy living summer camp program that draws campers from around America (and some foreign countries) to evaluate alternative mid-fidelity prototypes and discuss using avatars and contextual/motivational applications. Screen mock-ups had some visual treatment and content of actual software screens but no system functionality. Additionally, we asked participants to explore the use of avatars and of virtual agents as either part of or separate from these applications. A structured protocol of questions was used. The adolescents first answered some general background questions (i.e., age, technology access questions, level of avatar, or virtual agent experience) and then reviewed mid-fidelity mock-ups of seven types of graphical embodiments of the character, for the virtual-self avatar or virtual agent (see Figure 1 for examples). The adolescents also provided their insight and design recommendations regarding specific attributes of the character(s), such as voice (options presented from professional recordings), accessories available to the character, and a facial expressions chart review. In the conceptual spirit of “show, don’t tell,” we provided participants with access to drawing tools and clip art at sessions and invitation to act out there responses to communicate their recommendations and reflections of the visual and oral prototype review.

The adolescent participants then explored contexts for using these applications as well as barriers and facilitators. Testing included discussion of their perceptions of the community-based participatory research techniques.

Following this process, we conducted interviews of 10 providers (pediatricians and family practitioners) for their assessment the prototypes. The interview protocol focused on their thoughts about use and integration into practice; general reactions to the design of the avatar, challenges, and barriers; reactions to some key insights from the usability assessment; and the potential use of avatars and virtual agents.

We restrict our coverage in this paper to the data informing the general use of avatars and virtual agents for self-management of adolescent overweight and obesity.

Data Analysis

All focus groups, interviews, and usability walk-throughs were audio taped, transcribed, and then reviewed for transcription errors before data analysis began using qualitative data analysis applications (Dedoose (c)). We applied guiding principles from to move data to description and thereby develop understanding and insights. Analysis consisted of open coding of question responses by two members of the research team to create descriptions by identifying and defining themes related to technology innovation and program success.²⁷ Themes and classification schemas emerged through the research process. As the research team discovered new concepts addressed by the interviewee that did not map to the existing codes, we created a new code, typically a child code, to explain a finding or highlight a detailed characteristic of a case for each new concept. We used these child codes to understand the similarities and differences between the

Figure 1: Sample Avatar Prototypes.



implementation modalities. The initial phase of data analysis was complete when the schemas, involving design characteristics and challenges, appeared stable and the researchers reached consensus.

RESULTS

Role of Avatar and Virtual Agents

Table 1 provides an evidence trace of themes and research insights regarding the role of the avatar and virtual agent supported by the data. Data indicated great interest in including avatars and virtual agents to assist with self-management efforts and make self-management more “fun,” “entertaining,” and motivating. As stated by one teen: “I guess, because there is so much technology today if you have an avatar it does make it more fun.” Providers expressed considerable excitement and enthusiasm for using avatar and virtual agents as part of a lifestyle modification: “I think anything that will get the kids into using it is appealing and useful.” Expressly, providers were receptive to using avatars as another source of motivation for their patients: “Anything that makes them interested that they like, I am all for. I don’t care what motivates them, as long as they are the ones that are motivated. . . . Because that’s the only thing that works with the kids. They have to want to do it.”

Many teens responded that they had previously used avatars and were familiar with avatars in video games which they can control with their mouse and keyboard or with external specialized hardware devices such as Wii, or Xbox: “You would . . . make an avatar and it would like look [like you], its weight would be kind of like your weight.” The participants viewed the avatars as a way to set future goals with respect to how they look. “I think it’s a wonderful idea because a lot of people just stare at the avatar they make and go, ‘I want to be like that.’ And that’s a great way to get it started.” Teens also indicated that the avatar could serve as a coach, buddy, teacher, and motivator; and that virtual agents should be designed to provide empathic support and guidance. In the following paragraphs, we discuss each theme suggested as roles for the avatars and virtual agents.

Coach or Teacher

The teens envisioned the virtual agent as being useful when the teen was physically active and as a means to stay mentally active in achieving their self-management goals during inactive times. The avatar embodying a knowledgeable coach or teacher (virtual agent) could be a learning tool about healthy habits and behaviors: “I think it would provide extra coaching.” The teens were very open to taking advice from the virtual agent, for example in guiding healthy food choices when at home and out at restaurants.

Providers viewed the knowledgeable virtual agent coach role as an extension of the motivation and information provided in their interactions with the teens. “. . . and [cheerleading is] exactly what I view my role as when my patients come in to see me for obesity problems . . . I give them information, I help them set goals, etc. But I am not in their home, they have to do it on their own, my role is to be their cheerleader.” “And I think the . . . personal cheerleader, your personal life coach . . . if very much needed but there are really not enough healthcare providers to provide that So, if you can create a super cheerleader that they like, that’s awesome. Those little things help a lot” Providers spoke to the importance of positive reinforcement from the virtual agent rather than criticism of the teen user for poor choices. “. . . that coach avatar could have positive reinforcement It’s a fine line between coaching and criticizing, and you know what I would be really careful about it, not to be critical or to have a child feel like somebody is trying . . . to be critical.”

Teens also expressed a desire to learn from their virtual agent acting as a teacher: “. . . have it [be] a little classroom in there. So, you could go to the nutrition area and be like, okay, I’m in the classroom.” Some providers felt that the team approach to providing weight care in clinic could be used for educational technology by providing multiple virtual agents ranging from dieticians and exercise physiologists to cooking helpers to facilitate associations with the concept of extending human services. “Oh that would be awesome . . . would it be like diabetes dietician avatar, . . . exercise physiology . . . I wonder you know, some of the kids might like . . . a little chef, a person that’s the chef, they could show them how to . . . cut and cook and bits and temperature”

Buddy/Virtual Me

Many teens indicated the need for two virtual characters, one (autonomous) virtual agent embodying the teacher or coach to look up to for knowledge and advice and another one (self-controlled) avatar embodying a representation of them. Teens saw the animated characters as a source of fun or a buddy to spend time with or a virtual self-representation. The functions performed by this role included “weight calculator”, hangout companion, friend, funny, and motivator. As a weight calculator, avatars could exhibit physical changes, both outwardly and within the body: “. . . the more healthier you got . . . it will show how . . . how parts of your body would function better? That will be great.”

Other virtual agent uses included motivation and advice on healthy eating and exercise. “. . . once you log on, you have your avatar smiling . . . at you . . . like it will say something to you like, ‘Hey, you know, today’s daily fact is eat five servings of fruit.’” Providers saw the potential benefit of emoting to a “buddy” avatar: “. . . the teenager can

Table 1: Evidence Trace Table—Role of the Avatar and of the Virtual Agent

Theme	Code	Sample Supporting Quote from Phase 2 Data Collection
Concept of Avatar	Fun and Entertaining	"I think it's a wonderful idea because a lot of people just stare at the avatar they make and go, "I want to be like that." And that's a great way to get it started."
		"... pretty cool... an avatar that you track really and something started off as a big avatar and then have it calculate pounds and then take off the weight of the avatar as you do..."
	Motivation	"... Like if you have a frown face or something like that... "Come on, you can do this." you know" or, "Altogether, you're doing great. You're doing wonderful. You can have this."
		And somebody could motivate you, gives you the code of the day, you know, those little things helps a lot, you know, give you positive feedback, give you a quote stat a day, sounds really."
Role of an avatar	Coach	"I think it would provide extra coaching and I also think... a lot especially teenagers they get distracted easily so if they are actually watching something it will be easier to stay focused on it."
		"If... the teenager can express the feelings through their avatar or depending on how they are doing the avatar can be changing. And I think the... the idea of having a coach that sometimes, I think the personal cheerleader, your personal life coach, which is very much needed but there is really not enough healthcare providers to provide that. And then launching program, childhood obesity program in the community or the hospital at least may try, there is not enough of us. So, if you can create a super cheerleader that they like, that's awesome."
	Teacher	"I'd say the same thing. It could be like a teacher, you can make more avatars like that and then make it like a classroom almost. So, you could go to the nutrition area and be like, okay, I'm in the classroom or somewhere."
		"It would it be like diabetes dietician avatar, a you know, exercise physiology, like a Jillian Michaels... some of the kids might like that, a little chef, a person that's the chef, they could show them how to you know, cut and cook and bits and temperature and all that stuff."
	Buddy	"The main avatar that you create is going to be your buddy or your best friend or your sister or something, you know?... But I would say the main person that you make is your best friend for life and all of them are here to help you, basically."
	Virtual Me	"I'd like it to be a representation of the person that's using it. That way... it'll like help them realize more, "Oh, I can do this.""

express... feeling through their avatar or depending on how they are doing the avatar can be changing."

The adolescents indicated that the buddy avatar could serve as a surrogate to receive rewards such as new clothes, exercise equipment, or accessories in response to the teen's healthy behaviors.

Contexts of use

The adolescents felt the avatars and virtual agents could reinforce the guidance and support provided from lifestyle modification programs and that interacting with the avatar would fit within their lifestyle. Table 2 provides an evidence trace of themes and research insights regarding the contexts of use supported by the data.

When

The teens wanted the avatar and the virtual agent to be available when they were "on the go," at the gym, during exercise, when they were hungry, or needed a reminder. They also wanted to be able to use it when they needed something to do when bored, mornings before school, were home and alone, on the bus or any time they were motivated.

Where

Teens wanted to use the virtual agent mostly at home to review goals and progress and to create a healthy meal: "... help you if you are at home alone [and] need to... cook)." They also mentioned using the virtual agent at restaurants, to help with picking healthy foods from

menus and sticking with their meal plan. Teens also indicated use when with a friend "... to do things like just hang out with or play the games..." Regarding school, many felt that they would like to use the avatar and the virtual agent to help with food management, but they may not be allowed to access the technology.

Time

Results varied regarding usage time with a common thread indicating that the avatar and the virtual agent might be used daily to once a week at first, then probably less, depending on the experience. Successful health results would be the primary motivator for continued use of the avatar and the virtual agent, and engagement to reach healthy lifestyle goals and proper management of self-care.

The ideal duration of avatar or the virtual agent interaction varied from quick tips and reminders to hours of game playing or cooking lessons. Many stated that the duration was completely dependent upon the specific activity. For example, teens would only want to spend a few minutes using the avatar for recording food intake or physical activity, as opposed to spending longer using the virtual agent when learning healthy habits or "hanging out with a virtual me." However, teens also stated that in a busy lifestyle with school and other activities, finding time to connect with the avatar or the virtual agent could be a major challenge. It is "... going to be different every time just depending on what kind of days I have because every day is going to be different."

Table 2: Evidence Trace Table—Context of Use

Theme	Code	Sample Supporting Quote from Phase 2 Data Collection
When	On the go	"... at my computer, on the go sometimes."
	During exercise	"Maybe after like my daily exercise or something like that."
	Hungry	"Whenever I... eat something at night, like whenever you really want a snack... at nighttime or in between breakfast and lunch."
	As a reminder	"... reminding me that you can have a snack but it makes it like, portioned and healthy."
Where	Home	"I'd probably be at home or at least after gym or something, you know?"
		"Probably at night, like when I'm not really that active, because... you're staying active mentally."
	School	"Maybe at school if we are allowed to."
Travel	"On the bus because I have my phone or something."	
Time	Frequency—varies	"Maybe an hour or... if you are just bored you might talk with for like hours."
		"They are going to be different every time just depending on what kind of days I have because every day is going to be different."
	Duration—depends on activity	"It depends, if you are just going on there to get the food diary I would say maybe five or 10 minutes but if you are going on there and... it asks you why you've been eating so much or something and you have to fill up the little – of reasons, that would probably take 30 minutes, because it gives you tips and then you will be saying yes or no, interactive things basically a friend – kind of like an interactive friend you could talk to."
Platform	Computer/iPad/ iPhone	"It could be on your phone, it could be on your computer, it could be pretty much anywhere when you are using it."
Co-Users	Family	"I would share it with her because, you know, come on, mothers will want to know, "Hey! What are you on?""
	Health Camp counselors	"I'd definitely share it to the camp counselor with how I'm doing."
	Friends	"I'd like a sharing rule (with friends)."
	Doctors	"... and doctor. I would show what I'm eating at home, like a food diary to my doctor because my doctors, they can't monitor you."
	Personal—no sharing	"I don't think so, I would want to be like a personal thing."

Platform

Use of the avatar on multiple platforms was desired to facilitate access: "It could be on your phone, it could be on your computer, it could be pretty much anywhere when you are using it." Although use on smartphone or iPad was desired, some thought those might be too small to use the avatar feature. As a solution, teens indicated that the avatar might have less robust features if accessed on a mobile device.

Co-Users

The adolescents felt that sharing the avatar with family, camp counselors, friends, and doctors could be beneficial for setting goals, motivation, and distributing information. The possibility of adding avatars representing those you share with was also mentioned by teens in favor of sharing. If avatars were shared, participants indicated they could do exercises together, share media with each other, demonstrate use of the program or encourage adherence and goal setting.

Participants mentioned the need to share in a restricted social networking context (permission only). Even though adolescents indicated a willingness to share the avatar, they did not want the co-users to add/edit information related to their avatar. It is notable that some adolescents did not support the idea of having a co-user. They wanted the avatar to be personal and did not want to share it with anybody. "I don't think so, I would want to be like a personal thing."

Barriers and Facilitators

The overall theme we will discuss relate to technical difficulties, time, avatar and virtual agent design, personalized rewards, progress, and support. Table 3 provides an evidence trace of themes and research insights regarding avatar use barriers and facilitators supported by the data.

Technical Difficulties

Adolescents and providers identified technical issues as most important challenge to the use of avatars, especially the lack of Internet access or accidentally turning off features. It is of note that avatar and virtual agent technology could be embedded into a PC-based stand-alone program that does not require Internet access or only periodic access for updating or uploading user input meant to be shared.

Furthermore, the teens would find the avatar or virtual agent undesirable to use if they were required to continually update or pay.

Time

There were several time constraints mentioned, including: school and homework, extracurricular activities, and work. "When school starts [I'm] busy with homework and afterschool activities and work." Adolescents also viewed the busy schedules of their siblings and parents as potential issues that would keep them from using the avatar: "I have three sisters and we have a lot going on

Table 3: Evidence Trace Table—Barriers and Facilitators Results

Theme	Code	Sample Supporting Quote from Phase 2 Data Collection
Technical Difficulties	Lack of Internet access	"... I'm not going to have unlimited Internet access—on my iPhone and we don't have unlimited Internet at my house and so the only place I really get Internet is like friends or that's about it."
	Purchase add-ons	"On mobile and I think it would be more of a challenge to put everything in because like they have side stuff (e.g., advertisements) and downloads, and then like re-download, and then purchase things using actual money. I don't like that because I think it's kind of dumb, because if you're using it to help you lose weight like in general like some games like that, they're like if you want to move further without doing this you have to pay or yeah..."
Time		"Not having time to do it. You could have a little button in the corner that says pause or... "I ran out of time". It could save right then and so you can get back to it if you log right back in."
		"I mean especially when school starts I'll be busy with homework and afterschool activities and work."
Avatar Design	Fun	"Its extra fun, if I make everything a little more fun because I watch those cooking videos out there, they are just kind of boring, yeah. And, you watch them you have got other kind of boring. I think it would be a little more fun if they had – if they were cartoons instead of just regular people."
	Creative	"I don't like the boring avatars where all of them dress up like everyone else. I mean... , if I find someone who really owns an outfit. I will try to, maybe copy them a little bit but I don't really do that a lot."
	Identifiable with self	"Yes, and I'm pretty much the same. I try to make myself like my avatars as much as I can without showing more of my identity in the real world."
		"An avatar that looks like me... Yeah. And has kind of like a personality like me."
	Not a superhero	"I honestly do not like superhero avatars because I just don't find them fun or amusing or anything.."
Customize/personalize	"We can change the skin however we want. There is different kinds of skins people have and it... you can change it like graphically whenever you want to."	
Personalized Rewards		"Adding new stuff there. Like new rewards. You can update it."
Visual Progress		"... knowing that if I lose weight and if there was a section that says how much did you average okay... I would put in how much I weight, and then it calculates for me - congratulations and shows my body shrinking or whatever it's going to do. And then, over time I can just see. I think what would be cool is if you could have it show your success throughout the month. Month one and I will take a snapshot of your avatar and then four months later you can see how much the outside and the inside of your body has changed."
Family Support		"... everybody in my family now is trying to help me by doing healthy things now and so when I get back to do healthy things so probably my whole family."

throughout the day and my mom goes to school because of her job..."

Avatar Design

The adolescents indicated that they would be motivated to use the avatar and the virtual agent if they were more fun, creative, or if they were more "human-like," interactive, communicating, and indicative of progress or success. Teens indicated enjoyment in using avatars that they could identify with physically, emotionally, and ethnically or culturally. The desired appearance of the avatar varied across and within gender and age groups and the desire for personalization was strong. Preferred types of avatars included fantasy characters and a range of cartoon to realistic self-images (a few younger participants showed a preference for animal characters). Strong, fit, or superhero-like avatars were mentioned as types that were not interesting. Adolescents noted changes in taste and maturity as potential barriers: "... it might get more boring..."

A common theme was the desire for customization of the avatar (e.g., to represent various races and cultures). As the adolescent grows up and their interests change and mature, if the avatar is

unable to change with them, i.e., be customizable, the adolescent could lose interest. Adolescents were interested in avatars that would mirror their wide range in personality and interests. Teens wanted "... an avatar that looks like [them]... a personality like [them]..." or is completely different and unafraid to be themselves, "... they are... different from everyone else and they don't really care what anyone thinks. They [avatars] like to be outcasts and... be really cool... they are not like anyone else, and... that's not boring."

The avatar design may also influence the adolescent: "I try to make myself like my avatars as much as I can."

Personalized Rewards

The adolescents indicated that they would be motivated to use the avatar if they got rewards, new characters, or accessories. They were interested in being able to "unlock" new items and updates (gain access to accessories/rewards as a result of achieving goals).

Visual Progress

Tracking the adolescent's progress and weight loss through the avatar was identified as an important motivational tool. Specifically, seeing

the changes in their body reflected in the avatar, as well as being able to view the history or progression of those changes. “. . . *I think what would be cool is if you could have it show your success throughout the month . . . How much the outside and the inside of your body has changed.*” Adolescents want to see their avatar lose weight right along with them.

Family Support

Finally, motivation and support to use the application, the avatar and/or virtual agent from family was identified as an important social influence. Phase 1 interviews with parents indicated a general openness to limited interaction with computer-based interventions used by the teens, particularly if the parent was also self-managing a weight issue.

DISCUSSION

Personnel trained to support efforts toward healthy behaviors for overweight and obese adolescents are in short supply in medical or public health settings. Our results indicate that a well-crafted computer intervention including an avatar and/or virtual agent could potentially increase access to, extend the reach of medical programs, and provide overweight and obese adolescents with motivating experiences. The current study extends the support of teens, parents, and providers for adding avatars or virtual agents to traditional CBLs. Although we anticipate that some of our findings are relevant to other type of target behaviors, we primarily focus this discussion on the target population and their situation.

Our findings are in line with literature on intelligent tutoring systems, which has shown that virtual tutor agents play a crucial in keeping the user engaged.²⁸ Data supports the desire for a personal relationship with the avatar (representation of self) and virtual agent (independent representation of another) in support of previous studies. Teen participants showed interest in using a virtual agent as a surrogate for varying roles typically filled by providers and counselors. This may be an achievable goal as research shows that virtual agents are capable of expressing empathy, a critical success factor for providers employing lifestyle modification with their patients.^{12,14,29} Such studies demonstrate that if users are unable to form a social relationship with a virtual character, the impact of the intervention is marginalized.

Teens were willing to accept advice and information provided by a virtual agent, especially when the avatar was seen as a nonthreatening extension of them. Given the provider’s concerns about the balance between encouragement and perceived criticism, having the avatar deliver frank feedback could be a valuable asset in reversing obesity. This finding is in line with earlier studies that found that feedback on performance is better accepted from an avatar representing the user than another person.³⁰

Since the range of programmable features available for virtual agents or avatars is continually growing, it is a reasonable expectation for users to connect with anthropomorphic agents utilizing spoken dialog in natural languages and recognizable ethnic physical features.^{10,14,15,18,31–33} This may help reach at-risk groups.

Furthermore, there is evidence that interactions and “confessions” to a nonjudgmental computer-based intervention may be more honest and revealing than face-to-face encounters with a provider.³⁴ Expanded roles of the virtual agent as a virtual provider, which may more freely probe, to explore sensitive psychological and sociological factors contributing to obesity is a topic deserving study.

Specifically, results of this study provide a foundation that supports exploration of the use of virtual agents in motivational interviewing

(MI), behavioral tracking, and coaching. Behavior change interventions that use MI techniques have been identified as some of the most successful interventions to help individuals’ find and cultivate [the] *intrinsic* motivation to change.³⁵ In MI (and brief MI interventions), the motivation to change behavior is elicited *from* the client, and *not* imposed from without. Other motivational approaches that use a paternalistic expert role to coerce or persuade are not as conducive for identifying and mobilizing client’s intrinsic values and goals: confrontation usually reinforces the targeted behavior, and *direct persuasion generally increases client resistance, reinforces problem behavior and diminishes the probability of change.*^{36,37} Many challenges are involved in delivering MI interventions to people in need . . . such as finding the time to deliver them in busy doctors’ offices, obtaining the extra training that helps staff become comfortable providing these interventions, and managing the cost of delivering the interventions.³⁸

In congruence, our subject’s comments would support the acceptance of authority from the virtual agent. The adolescents expressed a desire to be an active part of the continuum of care, making healthier choices with the support of the virtual agent. Likewise, our findings are in line with current MI literature on behavior change regarding the importance of *positive* reinforcement.³⁵ Furthermore, MI interventions have been adapted to a variety of problem behaviors. Self-management of overweight and obesity can be a complex journey of managing nutrition, exercise, motivation, and socialization choices and behaviors. The prospect of using virtual agents and avatars to holistically fill gaps in education and coaching in each of these areas and allowing the teens to share their journal with a “trusted” avatar or virtual agent through motivational interviewing may be a positive reasons to include them in a weight management program.

In turning to the needs of providers, a program including an avatar equipped with preset materials on fitness training or nutrition and extending the provider’s reach into the teen’s home was exciting. This could answer the need expressed by providers in our study for multiple virtual agents (e.g., dietician, exercise physiologist). This type of multi-faceted technological support may encourage the general pediatrician to provide more comprehensive care for overweight and obese teens themselves and relieve some of the demand on a limited supply of medical specialists in this area (e.g., pediatric endocrinologists and preventive cardiologists).

This study makes strong contributions; however, limitations do exist. The limitations of our study, as with any qualitative case analysis, relate to generalizability and the potential of coding bias (though research methods were employed using structure and rigor to minimize bias). Although we collected data from teens and providers residing around the country, we derived our findings based on a limited number of sources of data. We invite future research to extend the study to various audiences and research methodologies to assess the boundaries of our findings. For example, using findings from the current study to inspire a large survey resulting in quantifiable data could be productive.

Furthermore, as the utilization of avatars and virtual agents within CBLs is a relatively new approach, we encourage further exploration of the barriers and facilitators addressed by the current study. We call for future research to examine the impact of a virtual coach capable of more complex relational skills such as responding nonverbally to a user’s emotional state and input.³⁹ Some examples of other relevant questions for future research include: what social cues are most important for virtual agents to recognize from the user and display in order to maintain rapport with and engagement of the user? What content and data about nutrition, physical activity, motivation, and the

user does a virtual agent require to be interactive and effective? Should the system be able to share the data collected about the user via electronic health records, and if so, how?

CONCLUSIONS

Given the possibilities of technology to augment existing structures, idealistic care models are not representing the full *socio-technical* “network of care” actually available to those with chronic disease. This study contributes to existing knowledge by providing evidence to reconsider existing models for potential inclusion of technologies, such as *medical avatars* and VHAs,^{10,16} to extend the existing self-care and chronic care models as part of the continuum of care. Specifically, the present study clarifies the use of avatars and virtual agents by providing insight on the role, context, and facilitators and barriers of avatar and virtual agents used in the context of adolescent overweight and obesity for those teens under medical care.

Overall, the community of players in the self-management process consulted provided support for avatars and virtual agents as well as avatar-integrated technology to assist efforts and provide motivational reinforcement to augment and keep teens on track with a healthy lifestyle on their availability/timeframe. The study further supports that prospect of using virtual agents and avatars to fill gaps in education, coaching and sharing their journey as positive reasons to include them in a weight management program. A novel finding regarding the continuum of care is that the combination of the self-avatar (exhibiting the same physical changes as the teen changes) with the virtual health coach(es) (providing help and pertinent advice) anytime and anywhere on the different platforms available to the teen during the day, was the most promising.

Findings also indicate multiple platforms are needed to support the adolescents’ preferences for anywhere access as well as screen real estate to accommodate complex, contemplative activities. Recent progress in WebGL and HTML5, which enable animation of sophisticated graphical 3D characters in real time on *any* browser, will facilitate the development of CBI function accessible from any browser, including web sites accessed from a mobile device.

Although the current study reveals that, there are barriers to address, avatars and virtual agents may have a beneficial role in augmenting the continuum of care by engaging teens and retaining their interests in a technology-based program that is built on evidence-based principals of intensive lifestyle management. CBIs can be more efficient, accessible, convenient, and less costly programs as well as scalable to meet implied demands as we move from treatment to prevention of obesity. Avatars and virtual agents tailored to user preferences and needs may prove to be a highly effective way to deliver a multitude of interventions.

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COMPETING INTERESTS

The authors have no competing interests to declare.

CONTRIBUTORS

C.LeR. – Design, data collection, analysis, writing, critical revision, and final approval.

K.D. – Data collection, analysis support, critical revision of the work, and final approval.

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