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REVIEW ARTICLE

Innovative interventions to promote behavioral change in overweight or obese individuals: A review of the literature

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The overweight and obesity trends have risen over the past few decades, placing significant burdens on health care in terms of increased morbidity and cost. Behavioral change therapy is an effective treatment strategy and includes goal setting, self-monitoring, problem solving, and reinforcement tactics. Traditionally, behavior change therapy has been delivered using face-to-face counseling along with paper and pen recording of dietary intake and physical activity. The current advances in technology provide opportunities to deliver interventions using cellphones, internet, and active video games. These new methods to deliver behavior change for the management and prevention of obesity are being developed in order to increase access, improve convenience, decrease cost, and increase participant engagement. In this review, we present new approaches to promote behavior changes in the management of obesity. Currently available data show promising results. However, future research is needed to address study limitations and implementation challenges of these innovative interventions.

Key words: Behavioral, exergaming, mobile apps, obesity, web-based, mHealth, weight loss

Key messages

- As technological advancements expand, there has been a fast-growing public interest in innovative, interactive, more convenient, and less costly weight loss and maintenance alternatives.
- Innovative weight loss interventions using web-based, mobile health, and active video games have been shown to be effective, but current literature supports mainly their use as an adjunct to traditional face-to-face interventions.
- More studies are needed to facilitate health care provider knowledge and trust in order to achieve successful implementation of these innovative behavioral interventions in the clinical setting.

Introduction

Obesity trends have dramatically increased over the past three decades resulting in a major global health burden (1). It is estimated that 11% of the population worldwide is obese, with rates as high as 31.8% in the United States (US), 32.8% in Mexico, and 71.1% in Nauru (1,2). Obesity contributes to roughly 10% of all annual medical spending in countries like the US (3). The association between excess weight and co-morbidities including diabetes, certain cancers, heart disease, stroke, thrombotic disease, osteoarthritis, sleep apnea, and liver and pulmonary disease is well established (4).

The increasing prevalence of obesity over the recent decades appears to be in large part due to behavioral changes supporting the maladaptive behaviors of sedentariness and consumption of larger, energy-dense foods (5). Behavior-based weight loss interventions are part of a comprehensive lifestyle approach used in the management of obesity. These therapeutic methods are based on the reinforcement of healthy changes in diet and physical activity. Traditionally, the delivery of behavior-based interventions has been through face-to-face trained providers, group sessions, or commercial weight loss programs alongside paper and pen self-monitoring of diet and activities. In-person behavior weight loss therapy sessions are considered a component of first-line therapy due to their proven safety and effectiveness at achieving and maintaining weight loss (4,6–8).

Historically, clinical trials such as the Diabetes Prevention Program (DPP) and Look AHEAD have shown successful weight loss and subsequent cardiovascular risk reduction through the use of in-person behavioral interventions (9,10). On average, patients lose approximately 8 kg over a 6-month period while adhering to a high-intensity, in-person comprehensive lifestyle intervention (i.e. $\geq$14 sessions in 6 months) consisting of diet, physical activity, and behavior therapy (6). However, several factors have been documented as reasons why conventional behavioral change weight loss programs are underutilized. Lack of referrals from

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health care professionals, program availability, inconveniences of meetings (i.e. lack of time or transportation), patient embarrassment, and high financial costs are some of the commonly cited barriers (11,12). With rapidly expanding communication and media technologies, the employment of new and innovative methods to promote behavioral modification is quickly evolving, with intentions to address many of these traditionally cited challenges. In this review, we summarize recent studies regarding the utilization of methods such as web-based interventions, mobile health, and active video games to deliver behavioral change interventions for the management of obesity. Further, we focus on the limitations of previously reported studies and challenges of implementing non-traditional technical solutions for the prevention and management of obesity.

Methods

We conducted literature searches using PubMed looking for systematic reviews, meta-analyses, clinical trials, and randomized controlled trials from 2008 through 2013. The keywords 'obesity', 'weight loss', and 'intervention' were combined with other keywords for each of the three areas of focus: web-based ('web-based', 'internet'), mobile health ('mobile health', 'smartphone', text-message', 'mobile apps'), and active video games ('active video game', 'exergame'). Studies were limited to Humans and English language and were excluded if weight reduction was not the primary end-point or mixed interventions were used. This was in order to decrease variability. Google Scholar was subsequently used to obtain additional reviews not detected through the PubMed search. All retrieved systematic reviews and meta-analyses were reviewed. Specific randomized controlled trials that highlighted relevant areas of interest (i.e. costs, attrition rates, specific content of intervention, and satisfaction with the intervention) along with additional trials not included in previous reviews were discussed in order to update the review literature.

Result of literature review

Web-based interventions

Web-based intervention has been defined as a primarily self-guided intervention program using a prescriptive online program through a website in order to create positive change and/or improve/enhance knowledge, awareness, and understanding (13). Web-based interventions offer potential solutions to common barriers posed by traditional face-to-face behavior change interventions in the form of low cost, adaptability, anonymity, reachability/scalability, and ubiquity (14). Features of such web-based programs may include social networking with real-time support, goal-setting tools, alarm reminders, body mass index (BMI) calculators, food and exercise tracking, and a platform for sharing of ideas with peers.

Seven systematic reviews/meta-analyses were identified (15–21). Four meta-analyses concluded that although web-based interventions led to modest but statistically significant weight loss when compared to no intervention or minimal intervention (i.e. pamphlets and usual care with providers offering advice as they liked), this small weight loss was inconsistent and unsustained, leading to questions on its clinical significance (15–18). Three separate reviews concluded that a meta-analysis could not reliably detect effectiveness of the intervention due to the great heterogeneity of designs among web-based studies and the small number of comparable studies (19–21). The majority of studies, but not all, demonstrated greater weight loss or maintenance with the number of log-ins, self-monitoring occasions, chat room attendances, and bulletin board posts (15,19,20).

In a recent meta-analysis, 14 weight loss trials and 4 weight maintenance trials with a total of 4140 participants were evaluated (15). Subjects were predominantly female (82%), with an average age of 46 and BMI of 32 kg/m^2. Included trials were randomized and lasted between 4 weeks and 30 months. Web-based interventions led to a greater weight loss when compared to the control (i.e. minimal intervention). The mean weight loss difference (MD) was –1.5 kg; 95% confidence interval (CI) –2.1 to –0.9. Weight loss was significantly less when compared to face-to-face interventions (MD 2.1 kg; 95% CI 0.8 to 3.4). In another meta-analysis, the authors examined 11 randomized trials with similar population characteristics and concluded that when web-based interventions were used as a supplement to face-to-face interventions in overweight and obese adults (average BMI of 32.0 kg/m^2), additional weight loss was detected compared to those receiving face-to-face alone (MD –1.48 kg, 95% CI –2.52 to –0.43) (16). However, substituting the face-to-face intervention with a web-based intervention resulted in statistically significant less weight loss (MD 1.47 kg, 95% CI 0.13 to 2.81).

A great concern for web-based weight loss interventions is high attrition rates (22). A study by Bennett and colleagues, which was included in a number of systematic reviews, is worth noting as it employed web-based interventions in a primary care setting while using an incentivized approach to achieve low attrition rates (14). This was a 12-week randomized controlled trial with 101 participants with obesity and hypertension. The study was comprised of a racially/ethnically diverse, well-educated, mostly employed, middle-aged population with slightly more males (52%) than females. Patients were randomized to either a usual care group in which providers managed patient weight as they saw fit, or web-based intervention using an interactive weight loss approach. Results of this study showed a mean weight loss of -2.28 ± 3.21 kg (body weight of $-2.6\% \pm 3.3\%$) in the intervention group compared to a mean weight gain of 0.28 ± 1.87 kg (body weight $0.39\% \pm 2.16\%$) in the usual care group. It was observed that those with the highest numbers of log-ins achieved the most weight loss. Those who met log-in goals by week 10 lost -4.50 ± 3.29 kg.

Lastly, a few studies have looked at the cost-effectiveness of web-based interventions. A 6-month cost-effective assessment evaluating in-person versus internet-only weight loss interventions in overweight and obese adults (average BMI was 35.8 kg/m^2) found that although in-person participants lost more weight than their web-based counterparts (-8.0 ± 6.1 kg versus -5.5 ± 5.6 kg), life years gained (LYG) were comparable and the incremental cost-effectiveness ratio was significantly better for web-based users ($2,160 per LYG versus $7,177 per LYG) (23).

Limitations of currently available studies reporting web-based interventions

Several limitations exist in studies testing web-based behavior change intervention for the management of obesity. First, the great heterogeneity in study design precludes any conclusive statements on effectiveness at this time. Web-based interventions differ on many features including length of intervention, content, frequency of feedback, control groups, and use of social support tools. Second, the vast majority of trials were conducted in the US among a patient population that was predominantly white females in their mid-40s (15–20). The lack of diversity in the studied population limits the generalizability of findings. Third, multiple studies lack information regarding randomization techniques, adherence, and participant familiarity with the internet which

may contribute to several biases. Fourth, some have suggested that the inability to double-blind participants in this type of study may lead to a compensatory rivalry (the 'Avis effect') which may weaken the effects of the web-based intervention (17). Lastly, higher attrition rates among the web-based interventions compared to the face-to-face groups limit intention to treat methods and affect the power of the study to detect a weight loss difference (16,21). However, it is worth noting that many of the drop-out rates in these studies remained lower than rates observed in some weight loss drug trials (7,21).

Challenges of implementing web-based interventions

Major barriers to implementation of web-based weight loss interventions exist. These include limited access for at-risk populations, ineffective communication between the intervention and the individuals, lack of evidence-based strategies at the expense of engaging participants, potential breaches in confidentiality, and lack of reimbursements for providers (16,24).

Although web-based interventions have been found to be less costly, those at highest risk for obesity prove to be harder to reach, partially due to a lack of resources (23). A recently released data report from the Pew Internet and American Life project showed that the vast majority of online health usage is performed by young, non-Hispanic white females and those with higher levels of education and income (25). This profile is in stark contrast to the high obesity prevalence subgroups which consist of minorities, those of lower socio-economic status and lower levels of education (26). Moreover, males are now gaining weight at faster rates than females (27). Greater effort will be required to support the dissemination of web-based interventions to these higher-risk populations.

Another often-overlooked problem in successful adoption of behavioral modification interventions is the inability to sustain communication with the individual effectively, leading to poor adherence. Tailored, interactive communication that also reaches individuals on an emotional level has been shown to be more effective than generic, one-way messages (28). Currently, there is great variability in structuring of web-based interventions, with some websites having more evidence-based strategies than others. Moreover, participants using the internet may develop tolerance to stimuli, face difficulties navigating the website, or become distracted by other online activities leading to poor adherence (17,28). It is essential that areas of user interface and evidence-based methods marry in a way not to compromise one another. Websites should remain simple, provide strong tutorials, avoid repetition, use evidence-based strategies with increasing intensity, and offer rewards in order to keep subjects engaged and promote adherence (5,17). Given that wide-scale implementations of web-based programs often suffer from early technical glitches that may affect consumer morale, such programs should be rolled out gradually (29).

With more evidence-based research aimed at resolving questions such as key components and the level of engagement needed for benefit, more clinicians are likely to inform patients of proven web-based weight management programs which will increase trust and usage of these programs. Further discussion is needed in regard to ensuring patient confidentiality and reimbursing providers for their roles in web-based interventions. At this point, effectiveness data remain clinically inconclusive due to great heterogeneity in trials. However, there is growing evidence suggesting that when detailed structuring is employed, web-based interventions are a safe and cost-effective tool which may be used as an adjunct to traditional face-to-face behavioral modalities.

Mobile health interventions

Mobile health (mHealth) involves disseminating medicine and public health through the use of mobile computing and communication technologies including mobile phones, personal digital assistants (PDA), tablets, and portable media players (30). Mobile health via mobile phones provides a more convenient and personal way to communicate, educate, share, and monitor health conditions through text messages and mobile applications (apps) (31). At the core of mobile phone technical abilities are voice and short message services (SMS or text messages), but many 'smartphones' have now evolved to include apps, internet, camera, and video technology. These new capabilities of the 'smartphones' facilitate the access and interactivity in mobile web- and app-based interventions (31). The ubiquity of mobile phones allows for a health care platform which eliminates many of the disparity barriers seen with traditional face-to-face and web-based interventions. As of 2013, 91% of the US population own a cellphone (32). Meanwhile, ownership of a 'smartphone' amongst US adults has risen from 35% to 56% during the last 3 years. Furthermore, minority groups (i.e. African Americans and English-speaking Hispanics) with higher obesity rates are more likely to own a cellphone, make calls, and send text messages than their Caucasian counterparts (33).

Relatively few studies have been published examining the use of mobile behavioral change for weight management. We identified three reviews investigating the use of mobile phone SMS and/or apps to achieve weight loss (34–36). In a literature review of mHealth SMS-only interventions for obesity, among the 14 included studies, 11 demonstrated statistically significant beneficial effects on weight, diet, or exercise, while 3 studies did not show an effect on those same variables (34). Participants were overweight or obese and mostly female with mean age range from 10 to 65 years. The majority of studies used a theoretical or conceptual model for guidance. The authors reported that the utilization of SMS to deliver behavioral change interventions was feasible and acceptable in terms of patients' comfort and feelings that the intervention was helpful. Due to small sample sizes and variability in the studies, unanswered questions remain regarding optimal timing and frequency of delivery, content of messages, cost-effectiveness, and longitudinal data. It was concluded that SMS data remain at its infancy stage, but studies show its use offers multiple methodological advantages over traditional behavioral therapy.

Two studies, not included in the above review, are worth mentioning. First, a SMS-based weight maintenance study recently published sought to answer the question of SMS content and optimal delivery (37). This study randomized 120 participants with an average BMI of 38 kg/m^2 to receive behavioral promoting text messages with a content focus on promotion, prevention, or attention control. Promotion-framed messages focused on promoting success and rewarding these behaviors, while prevention-framed messages aimed at preventing failure and avoiding temptation. Participants received once-a-day text messages at 8.00 a.m. At 3-month follow-up, clinically significant weight reduction and maintenance were observed, most notably amongst the prevention group who lost on average 6.9 kg compared with the promotion and control groups who averaged weight losses of 6.6 kg and 4.4 kg, respectively. Nearly all participants reported they would like at least one text message in the morning to help keep them motivated for the day. This study supports a prevention-framed SMS intervention with daily, early-morning text messages as a feasible and acceptable health care delivery method for weight management (37).

A second SMS study explored an innovative weight loss approach in college-aged students using the commonly used platforms of Facebook and SMS (38). This 8-week study randomly assigned 52 students with an average BMI of 31 kg/m^2 to either a Facebook, Facebook Plus SMS with personalized feedback, or waiting list control. The Facebook Plus SMS group participants joined a private Facebook group where they received weekly content along with daily text messages, personalized feedback via weekly summary reports, and were instructed to select a 'buddy' to serve as a support person. The text messages were programmed to be sent daily with random intervals and different reinforcing messages prompting patients to monitor data. At completion of the study the Facebook Plus SMS group lost significantly greater weight than did the Facebook alone and control groups (–2.4 kg versus –0.63 kg versus –0.24 kg, respectively).

Aside from SMS, mHealth research in data tracking devices such as mobile apps is growing. Weight management mHealth apps have become more popular over the past few years. In 2012, 60% of 'smartphone' apps downloaded were weight and exercise-related (39). In addition to web-based features mentioned above, many apps offer accessories such as barcode scanners, Bluetooth, global positioning system (GPS) tracking, sensors, and pedometers. Literature on mHealth weight loss apps or PDA interventions is limited. Current studies consistently demonstrate high participant satisfaction and acceptance of mobile app interventions, but inconsistent results are noted along with numerous limitations (40,41). No stand-alone mobile application reviews were identified through our search, likely due to the limited studies that are currently available. However, two systematic reviews investigating the use of mobile phone apps amongst other mobile technology features included a total of three mobile app interventions (35,36). Both reviews contained a small number of studies (six and seven), and two of these studies overlapped. The mobile app interventions were very heterogeneous in design (games versus tracking tools), outcomes and measures (patient satisfaction versus weight loss), and results (effective versus ineffective). Both systematic reviews cautiously concluded that as a whole, mobile phone interventions had modest and beneficial impact on weight loss behavioral change.

Two recent trials specifically looking at integrating mobile apps into behavioral management showed promising results. A three-armed, parallel group, pilot trial comparing 'smartphone' app, website, and paper diary interventions in 128 overweight and obese volunteers (average BMI of 34.2 kg/m^2), using an intention-to-treat analysis, found mean weight change at 6 months to be –4.6 kg (95% CI –6.2 to –3.0), –2.9 kg (95% CI –4.7 to –1.1), and –1.3 kg (95% CI –2.7 to 0.1), respectively (40). Patient adherence, satisfaction, and acceptability were statistically significantly higher in the 'smartphone' app group than the others, while drop-out rates were lowest amongst 'smartphone' users. Likewise, Spring et al. demonstrated that amongst 69 predominantly male, middle-aged veterans, the addition of PDA monitoring of food intake, weight, and physical activity to a standard of care *MOVE!* weight loss program led to an additional 3.9 kg more weight loss than the standard group alone (42).

Limitations of mHealth studies

Research into mHealth weight loss remains in its early stage but is quickly growing (34). Some unique limitations of mHealth include the numerous apps available, heterogeneity in their components, and frequent updates in app designs and mobile phones that makes it more difficult to conduct clinical trials (31,39). Studies are easily subject to contamination of results since non-blinded participants are often seeking and using multiple weight loss methods (40). Participants may be made aware of new weight loss options while involved in the trial. Future studies should further explore optimal timing and frequency of interventions, provider–patient interaction, long-term weight maintenance, and cost-effectiveness.

Challenges of implementing mHealth interventions

The mHealth interventions share similar challenges with web-based interventions (see above). Despite data supporting effective weight loss with monitoring of diet (35,40,41) and the conveniences of tracking the data through mobile phones, few people use mobile phones in this arena. Recent data by Pew Research Center show that although 60% of Americans report tracking their weight, diet, or exercise, only 9% of them use online or app tools to perform this task (42). Although this number is relatively low, one may suspect it will continue to grow as popularity of these apps rises. A concern facing mHealth apps is the lack of evidence and theory-based weight loss strategies. Some suggest that many app developers focus more on user interface in order to keep consumers engaged than evidence-based methods (43). A study by Pagoto and colleagues investigated 30 weight loss mobile apps and found that, on average, most apps included only 18.8% of the 20 evidence-based behavioral strategies used in the Diabetes Prevention Program (44). Likewise, a comparative descriptive assessment by Azar and colleagues examined 23 of the top-rated free apps and found all apps to be very low in theoretic content (45).

Another significant challenge for the implementation of these interventions in clinical practice is that while people are already seeking weight management solutions many clinicians are not yet familiar with the different apps available and how to incorporate them into practice (44). Reimbursement for the implementation of these interventions in the clinical setting is also a major challenge (24). Lastly, as with other communication platforms, efforts must be made to secure data when used in a clinical setting.

Active video game interventions

Childhood and adolescent overweight and obesity prevalence in the United States remains high, affecting over one-third of this population (46). Although it is recommended that children and adolescents should receive at least 60 minutes of moderate to vigorous physical activity daily, only 29% of high school students reach this goal (47,48). The rise in traditional video gameplay is deemed a major contributor of inactivity and is associated with an increased caloric intake resulting in weight gain in the youth (49,50). Playing these games has been shown to cause a nearly 2-fold increase risk of obesity for every hour spent playing (50). Since the development of more physically interactive and sophisticated gaming tools, an innovative opportunity has emerged to help combat obesity, particularly in the youth, the elderly, and high-risk disability groups. Merging the words exercise and gaming, the descriptive term 'exergaming' is now being used to reference active video gameplay. Exergames have been played since the 1980s but did not gain much recognition until the twenty-first century as they began entering private homes (51). Video game consoles have now advanced in wireless and sensor technology such that full body motion can be detected, allowing for a more engaging experience that often mimics sporting activities, dancing, or standard work-outs. Exergaming is an attractive option for physical activity due to its growing popularity and its ability to engage users and provide a safe, family-friendly environment for exercise.

There are currently growing numbers of studies examining the benefits of exergaming on weight loss. Multiple studies have

demonstrated considerably higher heart rate, oxygen uptake, and energy expenditure in exergaming participants compared to those playing more sedentary games (52–54).

A systematic review by LeBlanc et al. that included 51 mixed study designs with sample sizes ranging from 1 to 322 comprehensively investigated the relationship between exergaming and several health behavioral indicators (55). Studies consisted of pediatric (age 3–17 years), predominantly male, overweight, or obese participants from eight countries. Trials were rated as of low to moderate quality. The authors concluded that exergaming was able to increase light- to moderate-intensity physical activity acutely but did not significantly contribute to the recommended guideline goal. Similar results were found amongst adults in another systematic review by Peng and colleagues (56).

In a small study by Graves and colleagues, not included in the above reviews, the authors reported that energy expenditure (expressed in kJ/kg/min) was significantly greater when playing active video games (bowling 190.6, tennis 202.5, boxing 198.1 kJ/kg/min) than when playing sedentary games (125.5 kJ/kg/min) or when at rest (81.3 kJ/kg/min) ($P < 0.001$) (57). A 20-week randomized study by Staiano and colleagues evaluating 54 overweight and obese (average BMI at the 94.7 percentile) African American adolescents reported statistically significant weight loss in participants using co-operative exergaming (–1.65 kg) versus competitive exergaming (–0.04 kg), and control group (+ 0.86 kg) (58). Self-esteem and peer support also significantly improved in the co-operative exergaming group.

Limitations of exergaming studies

A number of limitations have been noted with current active video game studies. First, heterogeneity of exergames (e.g. console, game type, and playing time) and short intervention periods hinder some conclusive statements (53,55,59). Second, the majority of studies have small sample sizes leading to underpowered data and inability to declare statistical significance (53,55). Third, measurement tools are susceptible to technical errors when attempting to capture body movements and intensity (57). Fourth, due to the quickly evolving field, many papers quickly become outdated as new gaming consoles, equipment, and video games are developed. More data will be needed on adherence and sustainability to assess long-term health outcomes better. Lastly, most studies are unable to show real-world effectiveness of the intervention since they are performed under controlled circumstances. The majority of the exergaming studies thus far have orchestrated the duration and intensity of activity and encouraged daily participation (60). Study participants typically have not been allowed the opportunity to select their game of choice. One of the few studies testing an exergaming intervention in a more naturalistic home environment found that when 78 children (ages 9–12) received two active video games and were allowed to play as they wished over a 12-week period, their overall physical activity remained unchanged (60). The authors concluded that these results were likely due to subjects putting forth less effort when lacking an external motivation source or a compensatory reduction in other physical activities was present.

Challenges of weight management with exergaming

Although evidence consistently demonstrates youth enjoyment of active video game play and a positive rise in energy expenditure compared to sedentary activities, translating this to a sustainable method to assist in reaching recommending physical activity goals proves to be challenging. Studies have suggested that the amount of physical activity from exergaming simulation is less than that achieved from participating in the actual event and on average does not meet the recommended amount of daily physical activity for children and adolescents (52,53,55–57).

A barrier to the widespread use of exergaming is their expense. Those with lower socio-economic status who also may reside in areas where outside play is unsafe are often unable to afford such luxuries (53,61). Providing free access to such games in local community centers or in clinics may not only allow a safe environment for physical activity but may also introduce the concept to families not aware of this alternative mode of exercise. Another challenge to dissemination of exergaming for weight loss commonly cited is the tendency for exergaming to decline over time due to boredom and technical problems (55,61). Dixon et al. conducted a detailed focus group study to assess children's and parents' perception of active video games and concluded that the likelihood of long-term engagement with exergaming depended on game content (i.e. story plot, variation, rewards), degree of challenge, other commitments, and child age, with exergaming seen as more appropriate for younger children than teenagers (61).

Discussion

This review of the literature provides a comprehensive update of web-based, mHealth, and exergame interventions and their potential to promote behavioral changes in patients who are overweight or obese. In summary, web-based interventions are more beneficial than usual care in achieving modest weight loss but are less effective than face-to-face behavioral therapy. Using traditional face-to-face care and supplementing this with web-based sessions may provide additional benefit in weight loss and improved costs. Mobile health provides variable platforms for disseminating behavioral therapy through web-based interventions, SMS, mobile apps, and PDAs. Studies show that this is a promising tool for behavioral weight management, but more work is needed to incorporate more evidence-based and theoretical strategies while keeping participants engaged. Exergaming is an attractive approach to help combat excess weight by increasing exercise particularly amongst the youth but may apply to other populations as well. Co-operative gameplay may offer reinforcement of behavior and provide psychosocial support. Improvements in light- to moderate-intensity physical activity have consistently been noted, but it is improbable that children will receive the guideline recommended amount of physical activity using this method alone.

Future directions

Many studies demonstrate potential benefit; however, the overall effectiveness of these innovative interventions remains inconclusive primarily due to great heterogeneity in trial designs, short durations, and small sample sizes. Furthermore, many web-based and mHealth trials have been poorly generalizable, with most participants being white and well-educated females. Studies have also been limited by high attrition rates (particularly in web-based intervention trials), lack of evidence-based modalities, technical difficulties, and boredom with the program. It is essential that these limitations be addressed in high-quality trials that also answer questions regarding optimal intervention dosing, cost-effectiveness, and long-term outcomes.

Multiple barriers to implementation such as providing access to at-risk populations, attending to regulatory efforts, maintaining patient confidentiality, and providing reimbursements for providers must be addressed. The Medical Research Council (MRC) framework for the development, evaluation, and implementation of complex interventions may serve as a guide for these new innovative approaches (62). It is unclear whether commercial actors versus public health services will be more effective at assuming

responsibilities in this field. Further dialog is necessary in order to blend user interface and evidence-based management techniques to create a successful model of care.

It is important that providers seeking to assist patients with weight loss do so through individualized care. Factors such as age, literacy, mobility, financial status, and social environment must be considered in addition to patients' accessibility and willingness to use technological tools. The spectrum of excess weight ranging from overweight to severe obesity also deserves thought since different groups face different challenges and will likely fare differently. As with other intervention platforms, technology-driven strategies are not a one-size-fits-all path to behavior modification. It is worth investigating an algorithmic approach to assist caregivers in deciding which type of intervention a patient may benefit most from.

Conclusion

There is great potential in leveraging weight managing behavioral strategies through the adoption of new and innovative technological interventions. The exciting ability of such tools to reach a diverse population with relatively low costs is a key driving force behind the surge of interest in these interventions. Furthermore, the current burden of the global overweight and obesity epidemic and the growing need for access to health care serve as great motivation for investment. One should expect continual advances to take place in this field.

Declaration of interest: The authors report no conflicts of interest.

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