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mHealth approaches to child obesity prevention: successes, unique challenges, and next directions

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Abstract

Childhood obesity continues to be a significant public health issue. mHealth systems offer state-of-the-art approaches to intervention design, delivery, and diffusion of treatment and prevention efforts. Benefits include cost effectiveness, potential for real-time data collection, feedback capability, minimized participant burden, relevance to multiple types of populations, and increased dissemination capability. However, these advantages are coupled with unique challenges. This commentary discusses challenges with using mHealth strategies for child obesity prevention, such as lack of scientific evidence base describing effectiveness of commercially available applications; relatively slower speed of technology development in academic research settings as compared with industry; data security, and patient privacy; potentially adverse consequences of increased sedentary screen time, and decreased focused attention due to technology use. Implications for researchers include development of more nuanced measures of screen time and other technology-related activities, and partnering with industry for developing healthier technologies. Implications for health practitioners include monitoring, assessing, and providing feedback to child obesity program designers about users' data transfer issues, perceived security and privacy, sedentary behavior, focused attention, and maintenance of behavior change. Implications for policy makers include regulation of claims and quality of apps (especially those aimed at children), supporting standardized data encryption and secure open architecture, and resources for research–industry partnerships that improve the look and feel of technology. Partnerships between academia and industry may promote solutions, as discussed in this commentary.

KEYWORDS

Childhood, Obesity, Mobile technology, mHealth, Screen time, Focused attention, Sedentary behavior

Implications

Research: Researchers should conduct process evaluation of mHealth approaches; develop more nuanced measures of screen time and technology-related activities; investigate the relationships between sedentary behavior, screen time, and focused attention; and partner with industry for developing healthier technologies.

Practice: Health practitioners should monitor, assess, and provide feedback to child obesity program designers about users' data transfer issues, perceived security and privacy, sedentary behavior, focused attention, and maintenance of behavior change.

Policy: Policy makers should support regulation of claims and quality of medical apps for children, standardized data encryption, secure open architecture, and provide resources for research–industry partnerships that improve the look and feel of technology.

Childhood obesity continues to be a significant public health issue, increasing children's risk for elevated blood pressure and lipid concentrations, musculoskeletal pain, depression, anxiety, bullying, and later heart disease, asthma, and diabetes in adulthood [1–3]. Poor diet, lack of exercise, food marketing, a built environment that promotes sedentary forms of transport and leisure, lack of sleep, and television sets in children's bedrooms are some of the multiple sources contributing to children's obesogenic environment [4, 5]. Behavior-based interventions are essential for prevention and treatment [6]. Many forms of behavioral obesity interventions have been tested in the past such as school, community, family, and physician based, which have shown moderate success [7–9]. Electronic media offers opportunities to extend current approaches and to develop new ones [8, 10].

POTENTAIL SUCCESS OF MHEALTH APPROACHES

Electronic mobile technologies (e.g., smartphones, iPod touch, tablets, wireless sensors, etc.) that can be employed in mobile health (mHealth) surveillance, prevention, and intervention efforts have become affordable, easy to use, and widely adopted across socioeconomic statuses and age groups in the United States [11, 12]. mHealth-based child obesity interventions can capitalize on flexibility, speed, and lower participant burden offered by mobile technology. mHealth tools have been successfully used as data collection devices, assessment tools, platforms for delivering interventions, devices for self-monitoring of behavior, and real-time surveillance techniques (see [11, 13–21]). Currently, a third of American cell phone users have used the phone to access health information, and 12 % of smartphone users have at least one health app [18].

ADVANTAGES OF MHEALTH FOR BEHAVIORAL INTERVENTIONS

mHealth offers some advantages over traditional face-to-face methods for delivering behavioral interventions. These include cost-effective dissemination, real-time data collection and feedback, lowered participant burden, flexible program tailoring, data for self-monitoring, on-body sensing devices for weight-related behavior information, a platform for adaptive interventions, and visually appealing, engaging multimedia modalities. First, mobile devices are widely used across age groups and populations, providing a cost-effective platform for health program implementation. This popular platform can be used to provide a large audience of children and adolescents with best practice approaches to treatment and prevention of obesity, such as increasing physical activity and decreasing sedentary behavior [9, 22, 23]. Second, behavioral data can be collected in real or near time, allowing feedback to be automatically delivered rapidly following a person's action (such as a bout of exercise). The small time interval between desired behavior and feedback may increase the likelihood that the action will be repeated [24]. Third, the time required for participation in research and interventions is decreased. Intervention components and survey requests can be delivered directly to a participant, a phenomenon known as "zero-geography" (see [25]), without travel for face-to-face interviews or being tethered to home-based telephone lines. Lower participant burden may translate to lower study attrition and increased participant motivation. Fourth, technology-based programs can be tailored and personalized. Software applications ("apps"), interfaces, and devices (such as mobile phones) can be personalized. Beyond large fonts for the visually impaired or automatic language translation, avatars could be tailored by gender or culture for participants' apps. Tailoring may increase effectiveness of a health behavior intervention [26, 27]. Qualitative research suggests that obese adolescents are enthusiastic about receiving tailored text messages during a weight management program, particularly messages that are positive, direct, and encouraging [28]. mHealth tools allow the potential for individualization on a large scale [29]. As adolescents are able to participate more in the personalization process, the intervention may become more interactive; an interactive program design has been associated with increased physical activity [30]. Fifth, users can easily obtain and track self-relevant information allowing them to self-monitor. Easily accessible reports about progress toward weight loss goals, fruit and vegetable intake, or physical activity may provide users with the agency needed to begin or maintain healthy behavior change. Sixth, on-body sensing technologies paired with mHealth systems can collect real- or near-time weight-related behavior data, providing users with more detailed goal-relevant information and researchers with objective assessment about participants' actions and contexts. Seventh, mHealth tools provide a platform for adaptive interventions [31]. Digital technology programs could use decision rules to deliver program components automatically, providing a specified dose depending upon participant actions [26]. Tailoring variables can be measured via mHealth tools and used to assign an optimum dosage of program components [26, 31] to participants in real- or near-time. Possibly, adaptations could be made and delivered repeatedly as the need arose within a study [26, 31]. Behavioral researchers may develop adaptive treatment designs [31] that accommodate new industry products [32]. Eighth, mHealth technologies could display visually appealing screens and present exciting, engaging, novel, entertaining games that make participation enjoyable [19, 33]. Web-based weight loss applications that provide visual feedback to users may improve success [34]. This benefit may increase compliance, maximizing the dosage that participants receive. Ninth, process evaluation information, both on program delivery and usage [35], can be collected in real or near-real time. These data may provide more precise estimates of dose information than previously possible, potentially revealing new relationships between program components and health outcomes. Tenth, mHealth approaches can leverage participants' extant social networks or create new social support networks to encourage behavior change. A recent review found that using social support networks was one of five strategies used in the design space of mobile phone health interventions [12] as follows: "(1) tracking health information, (2) involving the healthcare team, (3) leveraging social influence, (4) increasing accessibility of health information, and (5) utilizing entertainment" (p. 186).

CHALLENGES IN MHEALTH

mHealth interventions offer opportunities for new types of research, implementation, and program diffusion. However, there are significant challenges associated with using mHealth strategies in child obesity treatment and prevention. These include slower speed of scientific development and implementation compared to the mobile technology industry, difficulties of conducting transdisciplinary science, data transfer issues, security and privacy issues, barriers to long-term maintenance, and development and implementation with children and families. These specific challenges are described below. Policy and practice implications of these challenges are addressed in "CONCLUSIONS AND RECOMMENDATIONS".

The speed of research versus industry

Progression from scientific research, clinical development, and translation to clinical practice may be slow and less systematic than is ideal [36]. Yet, rapid rise and widespread use of mobile technologies [11, 18, 37] suggest that demand for new wireless connectivity devices (hardware) and applications (software) will push industry to develop newer products at even faster rates. As the speed of industry development increases, the window of time within which mHealth-based interventions can be developed, pilot-tested, and empirically validated will narrow. By the time that the research process is ready to support dissemination of the intervention to larger populations, the technology tested may have become obsolete. The mobile technology industry aims to create sleek devices and attractive software that persuade potential consumers and meet expectations of current customers. Consequently, the look and feel of industry products is professional, and the technology is regularly updated. However, industry products are not routinely tested for accuracy, reliability, validity, or use in clinical or preventive settings. In contrast, health researchers develop empirically validated programs, but the mHealth technology used is often outdated and cannot compete with newer industry products. The possible outdated look and feel of products made for health research may be especially poor at capturing and holding the interest of children, who are used to appealing commercial devices, technology, and software.

Data security and participant privacy

Privacy and data security are key issues for the mHealth community [38]. Global positioning system (GPS) data, medical records, and other mHealth information must be secured to protect patient privacy [38, 39] and to earn participants' trust. Wireless technology may increase the risk of unauthorized access by third parties; hence, standardized multimedia encryption (to ensure that video or audio files could also be securely transferred) prior to data transmission would help protect users [40]. Companies that manufacture apps tend to collect names, email addresses, and other personal identifiers when apps are downloaded, and this practice potentially increases risk for breaches of confidentiality [40]. Data security policies could be standardized by meeting specifications for encryption and secure communication [40]. Standardized data security policies would help create interoperability (i.e., functional exchange between systems) and minimize research participant risk [40].

Researchers at nonprofit institutions, such as universities, and developers in commercial organizations are the likely creators of software and apps. However, these two groups do not always aim to create interoperable platforms, and commercial entities may believe that doing so would decrease competitive advantage [40]. Researchers at universities are regulated by institutional review boards (IRB), which could require standardized data security policies. Organizations such as the American Telemedicine Association already provide administrative, clinical, and technical guidelines for telemental health [41]. Commercial designers may not be subject to oversight resembling IRB committees, although they may attempt to self-regulate. The US Food and Drug Administration (FDA) plans to regulate medical mobile apps as well [42]. The advantages and disadvantages of this planned regulation have been discussed.

Data transfer issues

Erroneous or mistimed feedback could be delivered to participants if data or server transfer issues occur, devices have low battery power, or other technical difficulties are encountered [25]. These issues could lead participants to disengage with the intervention or become frustrated, weakening program efficacy. These topics are current concerns in the field; recently, the 4th Annual mHealth Summit, sponsored, in part, by the National Institutes of Health, facilitated conversation about how to address them [43]. Downed servers could potentially cause intervention components to fail to be delivered or cause delays in reporting such that feedback to participants was no longer relevant (e.g., a text message that suggests a user has been inactive when, indeed, she has just returned from a run). Because participants in mHealth studies are unsupervised during data collection, the potential exists for people other than those actually enrolled in the study to complete survey data or provide biometric input. Under this scenario, even when data are transferred successfully, they will be erroneously attributed to the research participant. Missing data resulting from technological glitches could also cause difficulties for data analysis. However, mHealth approaches may result in less missing data overall than traditional pre-postmeasures. Data analytic techniques for missing data [44] and for this type of multilevel data are available [45].

Challenges of transdisciplinary science

Development of mobile technologies for behavioral interventions requires collaboration of teams composed of experts from many different fields [25, 46]. These fields often have different scientific processes and different field-specific "languages." Interdisciplinary teams have the additional challenge of learning to create new scientific processes that incorporate the processes and languages of different fields to solve novel problems. The development of team science approaches to using mHealth technologies may also help expedite the development of a common language, timeline, and research priorities among researchers from different fields [46]. Practices and support from industry may help to guide the development of collaboration standards for researchers across disciplines. However, guidelines for success in testing and dissemination may differ between stakeholders, and adding industry partnerships to the inherently transdisciplinary mHealth approach must be conducted carefully.

Maintenance of behavior change

One long-recognized challenge of weight loss interventions is sustaining loss after an intervention has ended [47–49]. A meta-analysis of structured weight loss programs in adults found that weight loss maintained long term was ≈ 3.0 kg after 5 years [47]. However, people in the general population do lose weight and maintain significant loses using strategies such as regular physical activity, low-calorie/low-fat diets, and regular self-monitoring of weight [49]. Family support is important for children's maintenance of healthy changes in obesity treatment [22], but programs that include a family-based component may be more challenging to implement over long periods of time. Part of the difficulty maintaining weight after a program may be that weight loss interventions have often treated a "chronic problem with brief programs" ([48] p. 369), although newer interventions extend this timeline [49]. A benefit of mHealth technology is that people can use their own devices to run weight maintenance apps long after participating in a study. This opportunity significantly extends the reach of mHealth interventions beyond what is possible with personnel-heavy approaches. A second benefit is that mHealth tools have the capacity to collect data frequently, unobtrusively, and in interactive ways that can boost self-monitoring adherence in weight loss programs [50]. Early studies into weight loss intervention were not able to record long-term progress as frequently and measurements may have been taken annually, providing very limited information about progress (or regress) within the year [48]. More recent designs have measured progress as frequently as once per week during early phases [51]. Yet, mHealth capabilities for data collection multiply the frequency and depth of information that can be measured about processes and outcomes of weight maintenance.

One potential long-term drawback, however, of mHealth-based weight loss interventions may be device dependency. Long-term weight maintenance relies on continuing to implement lifestyle changes [49]. Certain mHealth intervention designs that are effective in the short-term for weight reduction could potentially impair participants' ability to implement long-term weight maintenance behaviors. Specifically, interventions that teach participants to rely solely on the device to cue action, provide information, and otherwise enable lifestyle change behaviors may not be teaching skills that are transferable outside of the mHealth context. Consequently, when the devices are no longer available (e.g., people return them at the conclusion of a study or technology malfunctions on a personal phone are too costly to fix), people can no longer engage in the same behaviors (e.g., using a smartphone to self-monitor weight). mHealth programs that teach participants long-term strategies that they can implement either on their own devices, on devices they receive after participation, or on devices they are able to purchase using compensation from the study may better equip them for long-term maintenance. Alternatively, mHealth programs could use stepped designs in which participants first rely on the device for behavior change but gradually transition to cues in their own environment for maintenance. Although important to consider, these issues may become less problematic as devices and service plans become less expensive, and validated apps could be covered by healthcare or employee incentive plans.

Development and implementation with children and families

Children's short- and long-term successes following weight loss and management programs are benefitted by family and parent involvement [23, 52–55]. Yet, parents face barriers in completing long-term program requirements [56]. Group treatment designs may be a more cost-effective way to deliver family interventions than group plus individual-based formats [57]. Schools are a recommended venue for obesity prevention programs [23], but school restrictions on child mobile phone use in school settings limit intervention delivery. However, restrictions may be lifted as mobile technology increasingly becomes incorporated into educational curricula [58]. Children, as minors, are more vulnerable than adults and may have different privacy concerns. Parental acts of digital child supervision (such as text messaging to request the child's location) may interfere with children's desire for autonomy [25]. Parents and siblings could share usage of the same device, or friends may grab devices during play. When children provide information as part of a research study, data is protected by IRB-approved procedures. Yet, children may have a more difficult time fully understanding risks and providing informed assent; care should be taken when parental permission and child assent are not in agreement [59]. Further, outside the protection of researcher confidentiality, health and medical apps do not necessarily promise to protect user's data as strictly. Children's activities may be more difficult to track than adults'. Whereas adults often carry their cell phone in a pocket or purse, children may not regularly carry the devices. This could make it difficult, for example, for researchers using data from global positioning systems (GPS) to gain adequate information to draw conclusions about parent–child dyad activity. Mobile devices that children can wear, such as on arm bands, may improve tracking results. Some research suggests that parent-only interventions are effective for long-term treatment of child obesity [53], raising the question of whom to target for the best results. In addition, because mHealth interventions are mobile, children are likely to be in a varying array of contexts–school, home, family, or friend–when prompted. This increased variety in context may alter the efficacy of an mHealth program in ways not seen with paper-and-pencil or desktop-based avenues of program delivery. The places in which technology is used affect how devices are used and what they mean to users, a concept known as "technogeography" [25, 60]. Finally, gaining and retaining children's attention may require more engaging games or apps than needed for adults. Developmentally appropriate technologies will need to be used, but mHealth approaches offer great opportunity for offering novelty and excitement.

POTENTIAL SUCCESSES OF MHEALTH FOR OBESITY PREVENTION

mHealth approaches have shown success for diet and physical activity interventions in adults and children [19, 33, 63, 64]. Obesity treatment and prevention studies that use mobile-based, interactive technology and text messages may be preferred by adolescents over traditional paper-and-pencil approaches [19, 33]. mHealth types of technologies show promise for aiding self-monitoring adherence for diet and physical activity [19, 50]. Populations at highest risk for obesity may be more easily reached by mHealth approaches. In 2011, Black and Hispanic (English- and non-English-speaking) adults were just as likely as Whites to go online wirelessly [61]. Further, Blacks and Hispanics were more likely than Whites to use a cell phone to access the internet, send and receive email, and download an app [61]. Although a digital divide still exists–those with the lowest education level and income are least likely to own a smartphone–fully half (50 %) of people making <$30,000 per year and 53 % of those with only a high school education go online wirelessly [61]. Obesity prevention programs could be delivered to those at the highest risk using mobile technology [62].

CHALLENGES WITH MHEALTH SPECIFIC TO OBESITY PREVENTION

Although mHealth approaches show promise for the child obesity prevention field, researchers using these strategies face unique challenges. The following two possible, if unintended, consequences of screen time connected with mHealth could adversely affect obesity risk: increased sedentary behavior and decreased ability to focus attention.

Sedentary behavior and screen time

Both television use and snacking while watching television have been associated with increased sedentary behavior, but effects may be specific to the type of media, its content, or the context of delivery [15, 65]. Greater television viewing and other screen time has been associated with high BMI and adiposity in children [66, 67]. Results of a randomized controlled trial show that decreasing television viewing and computer screen time using a device to regulate screen use was associated with lower BMI *z*-score for children who had a BMI ≥75th percentile, mediated by changes in sedentary behavior [68]. Screen time sedentary behavior, such as television or video game use, has not been consistently associated with higher BMI, although many studies do find a significant relationship [65]. High levels of interactive media use (such as internet surfing and video games) have been specifically associated with BMI and body fat percentage in adolescent girls above and beyond the sedentary behaviors of television viewing, talking on the phone, and reading/homework [69]. The effect of screen time on adiposity may be moderated by the content of the media [65]. The variety of devices used, media multitasking, may affect adiposity as well [70]. Much research on screen time has been conducted on stationary devices such as televisions and desktop computers. As game use, media viewing, and other screen time become more mobile, research on the association between screen time and obesity risk will need to be updated. Potentially, the association could weaken if screen time becomes less sedentary as technology becomes increasingly mobile. Mobility of tablets and smartphones allows people to exercise while using media, potentially weakening the link. Healthier mobile technologies might ameliorate unfavorable effects of screen time on obesity risk. For example, apps could prompt users to move after prolonged periods of sedentary behavior, encouraging "sedentary breaks" [71]. Also, very little exploration has gone into development of pervasive games, outdoor augmented reality, and mobile games that could encourage connection with nature and social interaction [72, 73]. Parents, peers, teachers, and other social influences on child sedentary behavior and media use will be important to consider in studies and interventions as well. Our main challenge as a field is to break the connection between screen time and increased sedentary behavior. As children spend larger portions of leisure and entertainment time using a device with a screen, they will be healthier to the extent that they can be less sedentary. Research is urgently needed to understand which factors (e.g., environmental, inter- and intrapersonal, technological, media content, developmental, and social) influence the relationships between sedentary behavior, screen time, and obesity risk. Further, we must understand whether and how these factors can be modified. In whatever way the technology provides it, a crucial element for improving the use of mHealth for future child obesity prevention requires understanding and altering of the screen time/sedentary behavior connection.

Decreased ability to focus attention

Television and video game exposure have been associated with higher risk for attention problems in both cross-sectional and longitudinal studies [74, 75]. Multiple causes likely contribute, but at least two hypotheses have been advanced. First, the association may be due to adverse brain development from large amounts of fast-paced, attention-grabbing media content [75]. Second, children may become accustomed to rapid scene changes and find more slow-paced tasks, such as homework, boring [75]. Attention regulation difficulty, as a subcomponent of both attention deficit disorder and impulsivity, has been associated with overweight and obesity [76, 77]. More research is needed to understand potential causal relationships, but an inability to regulate attention may hamper inhibition of impulsive snacking episodes or interruption of long stretches of sedentary behavior. Media that is widely, instantly available, even if it contains messages about healthy behaviors, may need to be assessed for potential adverse effects on attention with respect to obesity risk. Importantly, the relationship between media, video games, cognition, and brain function is complex [78]. Video game use may beneficially affect visuospatial attention and mental rotation capabilities [78–80]. Exergames [81, 82] and brain training games may improve executive function [83]. The implications of "brain training" effects on the immature brain are not completely understood [84]. In brief, age differences could be magnified due to a lack of prior brain structures, increasing specialization may sacrifice plasticity and creativity, and the degree to which plasticity is possible depends on genetic and epigenetic factors [84]. Brain development occurs through positive social interaction and supportive social relationships; social neglect may lead to lifelong vulnerabilities in psychological functioning [85]. Children who interact with technology to the exclusion of spending time with other people may adversely affect healthy development. Designing prosocial interventions or electronic games is important, followed by modeling prosocial behavior in the interactions required between users/players of health games. The most negative aspect of traditional video games has to do with slot machine reward mechanisms. At a young age, overstimulating the hippocampus has implications for long-term aging problems [86]. Technologies that improve attention and self-regulation capabilities have the potential to strengthen children's ability to manage diet and physical activity behaviors. Partnerships between child obesity researchers and the mHealth industry could help shape technology development in the direction of creating healthier technologies. The critical challenge is twofold. First, we must understand the relationships between media use, decreased ability to focus attention, and obesity risk. Research is needed that identifies causal sequences, intervening mechanisms, and the degree to which these are modifiable. Second, we must leverage this understanding to develop strategies for confronting the associated obesity risk. Games that mimic real-life time sequences, instead of fast cuts, may not have the same effects on focused attention, suggesting alternative media designs would be helpful, or if the effects are the same or the media is less appealing, perhaps improved executive function, visuospatial attention, or mental rotation capabilities could be harnessed to offset the shift away from focused attention. For example, brain training for increased executive function may allow a child to use higher order self-regulation strategies to inhibit junk food consumption, thereby compensating for any effects on decreased focused attention. In sum, research investigating the underlying processes and influential factors on media use, focused attention, and obesity risk is critical.

CONCLUSIONS AND RECOMMENDATIONS

mHealth systems offer opportunities for surveillance and research in childhood obesity as well as development, delivery, and dissemination of treatment and prevention programs. The challenges of mHealth implementation include the relatively slower speed of scientific research versus the mobile technology industry, data security and participant privacy, data transfer issues, challenges of transdisciplinary science, maintenance of behavior change, and working with children and families. Although these issues confront the field, the advantages of mHealth tools are many. Flexibility, minimization of reporting bias, and entertainment value provide a compelling case for its continued uptake by health behavior interventionists. For child obesity researchers, mHealth tools provide an attractive platform from which to engage children and adolescents in monitoring healthy nutrition and physical activity, playing exergames, and developing cognitive capabilities. However, child obesity interventions that harness the power of mHealth may need to be designed and implemented in ways that direct sedentary screen time and focused attention in healthy, productive ways. Socioecological, clinical, and program evaluation of mHealth approaches will be necessary for ensuring efficacy (i.e., beneficial effects on health outcomes under controlled conditions) and effectiveness (i.e., beneficial effects in real-world settings) [87]. Two differences between the goals of efficacy and effectiveness approaches plague successful translation from the prior to the latter [87]. First, efficacy trials are often conducted in controlled settings on select populations of motivated individuals who do not have comorbidities, whereas effectiveness trials must demonstrate results across demographic, motivational, and diagnosis boundaries [87]. Second, efficacy trials are conducted in specific settings, and the context of delivery is typically narrow to provide a more precise test of the program components. Yet, effectiveness trials must deliver programs across a wide distribution of settings and multiple, possibly dynamic, contexts [87]. Most importantly, it should be noted that new research methodologies, appropriate for the fast evaluation of mHealth interventions, must be employed to fully capitalize on the advantages offered by mobile technologies, real-time monitoring, and the rapid advancement of technologies that can change during the development of an intervention [88]. The prevalence and popularity of mHealth delivery systems provide a platform that is user-friendly across participant and setting characteristics, allowing researchers to address these issues, hopefully increasing the likelihood that program delivery will result in real-world behavior change. Evaluation methods will need to be developed (e.g., [89]) and reporting standardized (e.g., [87, 90]). Health behavior theories provide frameworks for evaluation [91] and can guide evaluation of mHealth approaches. To use social cognitive theory [92] as an example, mobile delivery of avatars behaving in healthy ways would provide models and opportunities for observational learning. Frequent, real-time feedback provides incentives that may change relationships between participant self-efficacy and health outcomes. As another example, self-determination theory [93] holds that people are intrinsically motivated to seek challenging, novel experiences; fun mHealth games and apps may be able to provide new ways to promote intrinsic motivation.

Research recommendations

Designers of new child obesity treatment and prevention techniques, technologies, and programs will need to devise nuanced measures of screen time. Measures will need to assess media content, type of media, how media is used, multitasking while using media, social context, parent–child and peer–peer shared engagement, frequency, opportunity costs (e.g., other activities that children are not pursuing because of taking advantage of mobile technology), and perceived quality of experience, among other potential aspects. Media content that contains food marketing messages may change children's food preferences [94]. Media multitasking (using multiple media sources at one time) may rapidly multiply exposure [70]. However, parent engagement and coplaying of video games may increase connectivity within families [95], which could benefit parental influence on children's health behaviors. More nuanced measures of screen time will need to be developed for proper assessment of these contingencies and for assessment of social context (e.g., parents, peers, and teachers). These nuanced measures will have to focus on behaviors first instead of technologies because people use technology differently [60]. For example, ownership of a device does not imply or explain actual usage patterns or specific behaviors. Partnerships between researchers and the mobile technology industry may help conduct studies quickly when devices and apps must be updated to meet users' expectations about the look and feel of the technology. Significant opportunity exists for developers and researchers to reach beyond "gamification" [96, 97] and to design mHealth experiences and entertainment that go beyond implementation of random reinforcement schedules to create experiences that can truly support and monitor optimal developmental milestones. To promote healthy eating and activity, new games and apps could be designed that encourage physical activity or discourage sedentary behavior by prompting people to take "sedentary breaks" during extended periods of inactivity [71]. Applications could be developed to help people who have lost weight anticipate and self-monitor new challenges that may arise such as an increased appetite or decreased energy expenditure [98]. Child obesity interventions that capitalize on the strengths of mHealth tools are being developed, but additional research is needed.

Practice recommendations

The prevalence, ease of use, and flexibility of mobile technology create a strong foundation for cost-effective dissemination and distribution. Health professionals who use mHealth tools to implement child obesity programs may wish to monitor users' sedentary behavior, screen time, and focused attention. Guidelines for "behavioral equivalence" may be useful in order to understand how to implement and regulate a "healthy dosage" of technology, such as screen time that could substitute or enhance meaningful learning, social interaction, physical activity, or interaction with nature. Other issues such as increased social isolation, addiction to gaming, or electromagnetic radiation exposure with high cell phone use could be monitored as well [15, 65–69, 99–101]. mHealth tools and interventions continue to be developed and feedback from practitioners will be necessary to track and report practical challenges. Feedback from program implementers about program reach, adoption, implementation, and maintenance will be required for ensuring real-world effectiveness [87, 102]. Health practitioners will be essential in reporting accurately about user experiences with data transfer issues, perceptions of security and privacy, and maintenance of behavior change.

Policy recommendations

The pending US Food and Drug Administration guidelines propose to regulate medical mobile apps [42]. However, they do not specifically mention apps directed toward children, treating this vulnerable population as though they have autonomy and cognitive development equal to adults. In addition, the guidelines are focused on medical mobile apps that are treatment oriented rather than prevention focused. The benefit of this regulation is to protect those who could be harmed by apps. The drawback is that innovation may be limited during this relatively early period of development for the field, potentially preventing higher quality apps in the future. One possible solution for the interim is to crowdsource ratings for apps [103]. Although crowdsourced ratings would not be empirically validated, and limited evidence suggests that they do not yet provide the same results as controlled trials, standardization of patient input, response options, and other improvements may improve the value of crowdsourced ratings for consumers [103]. Examples of companies attempting to address this issue include the Medical App Journal (http://medicalappjournal.com), Happtique (http://www.happtique.com), and iMedicalApps (http://www.imedicalapps.com). A longer term solution, however, may entail regulating the claims and quality of mHealth apps, especially those directed at vulnerable populations, such as children. The structure of such protections might follow the example of Federal Communication Commission (FCC) restrictions on violent or explicit content to children (www.fcc.gov) or non-US policies regulating food marketing to children [104]. (For an interesting history of the struggle for governmental regulation of food marketing to children in the US, see [105]). Policies that support standardized data security procedures and interoperability, such as data encryption or open architecture, would allow sharing across platforms, support innovation, and may protect users [40, 106]. Policies could regulate advertisement of mobile technologies. Similar to the "Drink Responsibly" advertisements by liquor companies, technology businesses could advertise the responsible self-regulation of sedentary behavior associated with screen time. Policies that support special rapid funding mechanisms for mHealth technology-based research may improve rates of participant compliance and decrease attrition if adolescents' expectations about the look and feel of technology can be met with updated devices and apps. Policies could support the development of secure, open architecture technology and provide resources for including updated technologies in treatment and prevention trials.

mHealth systems can play a significant role in diffusing child obesity treatment and prevention programs to wide audiences of users across socioeconomic and age groups. The challenges facing use and diffusion may require cooperation across disciplines, development of new assessment methods, and close monitoring of weight-related factors such as screen time sedentary behavior and focused attention. Importantly, mHealth advances may provide a new channel through which to reach and engage large audiences of young people. The complex, challenging public health problem of child obesity will undoubtedly require multifaceted interventions. Harnessing mobile, multimodal, interactive mHealth tools broadens the range of resources available and opens the possibilities for different innovations than were possible before.

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