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Interventions for Childhood Obesity: Evaluating Technological Applications Targeting Physical Activity Level and Diet

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Interventions for Childhood Obesity:

Evaluating Technological Applications Targeting Physical Activity Level and Diet

by

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ABSTRACT

Overweight and obese children have increased risks for multiple preventable diseases and conditions which can impair their physiological health and significantly increases the overall cost of their healthcare. Free mobile applications and technology for weight loss, dietary tracking, and physical activity may be quite useful for monitoring nutritional intake and exercise to facilitate weight loss. If so, nurses are well positioned to recommend such tools as part of their efforts to prevent childhood obesity and help children and parents better manage childhood obesity when it is present. However, there are no guidelines that nurses can use to determine what applications or technologies are most beneficial to children and their parents. The purpose of this project is to develop such guidelines based on a review of the scientific literature published in the last 5 years. Articles regarding healthy-lifestyle promoting mobile applications and technological approaches to health and fitness interventions were identified by searching articles indexed by CINAHL, Psychinfo, Medline, ERIC, IEEE Xplore, and Academic Search Premier. Identified articles were assessed using Melnyk's hierarchy of evidence and organized into tables so that implications for research and suggestions for practice could be made.

DEDICATIONS

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Introduction

Free mobile applications for weight loss and diet are becoming more frequently used for tracking dietary intake and exercise to assist users in weight loss. However, many nurses lack information regarding which applications may be best to recommend for managing or preventing childhood obesity. This information is critical given the incidence of obesity from the American Nurses Association Issue Brief (2010), which stated that there are approximately 13 million obese children in the United States. In addition, there has been a significant increase in childhood obesity within the United States from 14.8% in 2003 to 16.4% in 2007. Obese children are likely to become obese adults with eight out of ten obese children remaining obese into adulthood (Jones, 2010). The purpose of this thesis is to: (1) review the evidence regarding the properties of effective technological applications and any studies testing the use of these applications in clinical practice; and (2) make recommendations for research and practice regarding which technologies nurses and practitioners could recommend to parents and children to support healthy eating and lifestyle behaviors.

Background

Nurses can play a pivotal role in both providing care and education to clients regarding childhood obesity management and prevention. Within the healthcare setting, nurses are often the first ones to receive patients in emergency rooms, primary care offices, school clinics, along with many other healthcare areas (Jones, 2010). Nurses are well-suited to promote healthy lifestyle choices through patient teaching and public health initiatives. The American Nurses Association (ANA) highlights several nursing responsibilities including: educating, advocating, and partnering in the prevention and treatment of childhood obesity (Jones, 2010). Through education and counseling, nurses can teach children and families about proper nutrition and the importance of physical activity. The nursing profession has partnered with the White House "Let's Move" campaign to promote healthy choices and physical activity in order to reduce childhood obesity from 20% to 5% by the year 2030 (D'Auria, 2011). Recommendation 5.17 of the campaign, calls for entertainment and technology companies to continue developing new approaches for the use of technology to engage children in physical activity (Barnes, Jacqueline & et al).

Problem

In the United States, approximately one-third of children, aged nineteen and younger are classified as overweight or obese (Hswen, Murti, Vormawor, Bhattacharjee, & Naslund, 2013). Environmental factors and social practices, especially poor dietary habits and lack of physical activity contribute to this increased prevalence of overweight children (Maier et al., 2011). A combination of consuming excessive calories coupled with a lack of physical activity creates an energy imbalance, which then leads to weight gain (Bäcklund, Sundelin, & Larsson, 2011). When considering physical activity level and other behavioral patterns, these factors can be significantly modified through interventions which focus on increasing physical activity, altering behavior, and reducing technological screen time (Bäcklund, Sundelin, & Larsson, 2011). More recent studies suggest that the increase in the prevalence of obesity may be leveling off due to increased awareness among healthcare providers, governmental agencies, and the public sector (Hopkins, DeCristofaro, & Elliott, 2011). Although the trend may be leveling off, the obesity epidemic has yet to be reversed. It is evident that interventions are still needed to address the pediatric population classified as either overweight or obese.

Significance

Diet and physical activity remain of great importance for improved health, reduced mortality, and weight loss in those who are overweight or obese (Bäcklund, Sundelin, & Larsson, 2011). The World Health Organization's International guidelines recommend that children and adolescents engage in physical activity for at least sixty minutes each day (Sola, Brekke, & Brekke, 2010). Overweight and obese children have increased risks for multiple preventable diseases and conditions such as metabolic syndrome, cardiovascular disease, insulin resistance, type II diabetes, atherosclerotic plaque formation, musculoskeletal impairments, cancer, respiratory conditions, renal impairments, psychological conditions (i.e. risk for social stigmatization, poor self esteem, and bullying), left ventricular hypertrophy, and several other preventable conditions (Hopkins et al., 2011). If these children's weight issues are left untreated, experts advise that this may be the first generation to have life expectancies shorter than their parents (Hopkins et al., 2011). In addition to shorter life expectancies, the obesity epidemic comes with significant financial costs. In 2002, the direct and indirect costs of obesity were estimated to be approximately $92.6 billion dollars (Gance-Cleveland, Gilbert, Kopanos, &

Gilbert, 2010). Thus it is critical for nurses to actively promote better nutrition and healthy lifestyle behaviors in children to reduce their future health complications and the long term healthcare costs.

Many attribute this decline in physical activity to an increase in media television and screen time (Bäcklund, Sundelin, & Larsson, 2011). However, Vandewater and Denis (2011), found that, “despite high levels of media use and a high incidence of obesity among youth, evidence that these concurrent trends are strongly related is poor.” Media and technology is more likely a potential “cure” than a cause of childhood obesity (Hswen et al., 2013). For example, Maier et al. (2011) found that children aged 5-8 years old spend approximately 2.2-2.6 hours daily in activities such as: watching television, playing on the computer, and listening to music. Whereas the same children reported spending 0.6-0.8 hours being physically active in activities such as riding a bicycle or playing outside (Maier et al., 2011). Technology has the potential to be used as a “consumer-first approach” (Hswen et al.). Further, Hswen et al. argues that technological applications have considerable potential to improve children’s health because their planning and design can be driven by a consumer first approach.

Among children, adolescents, and adults, mobile phone and technological applications have the potential to be maximally utilized in the public health sector. Currently technology is a tool which serves many purposes including business, leisure, information sharing, health, education, and numerous others. Boulos and Yang (2013), noted that Smartphone and mobile phone user adoption rate has “exploded in recent years and is said to be growing faster than that of any consumer technology in history.” According to Hswen et al. (2013), fifty-two percent of children under eight years old have access to Smartphones or similar mobile devices. This widespread use in combination with the accessibility and portability argues for the use of mobile applications for health promotion (Baranowski, & Frankel, 2012). In addition, children are considered “technological natives” in that most have grown up with mobile devices and are quite proficient in their use already (Vandewater & Denis, 2011). Hence, this thesis will review the evidence regarding the use of technological application technology for promoting healthy eating and lifestyle behaviors for children.

Method

A literature review was conducted to identify articles published in the past five years regarding healthy-lifestyle promoting technological approaches to health and fitness interventions. Since technology changes rapidly, the last five years of evidence was used in order to ensure that any practice recommendations would involve the most recent development in technological applications. Databases searched for health science journals included: CINAHL, Psychinfo, Medline, SportDiscus, ERIC, and Academic Search Premier. The IEEE Xplore database was utilized to identify articles in the computer science literature, not indexed by the latter data bases. Search terms in the health science databases were “((MH "Wireless Communications") OR "WIRELESS communication systems" OR "CELL phones -- Research" OR (mobile AND technology) OR (mobile AND phone*) OR app* OR apps OR "World Wide Web Applications") AND ((MH "Obesity") OR "childhood obesity" OR obesity) AND (child*) NOT ("news trends").” In the computer science IEEE Xplore search, terms included “mobile AND health AND diet*.”

Inclusion criteria for articles identified through these searches were English language and specifically addressing the positive effects of technological applications for promoting healthy eating and physical activity. Exclusion criteria were: journal articles published prior to 2008; interventions involving a cell phone text messaging system only; apps for infant obesity screening; and web based computer interventions only. Once articles were identified, an ancestry approach was then used to supplement the pool of articles meeting these criteria.

The resulting set of articles was then divided up according to the category of technology described (mobile phone applications, exergame, and mobile application with activity sensor) and ranked according to hierarchy of evidence using Melnyk and Fineout-Overholt's (2005) hierarchy of evidence. This ranking was used to evaluate which articles contained the most valuable and promising information with which to guide practice (Stillwell, Fineout-Overholt, Melnyk, & Williamson, 2010). This hierarchy was used to assess the general state of the science with respect to each category of technology.

Results

A total of 93 articles were identified initially in the search of the health science journals with 9 found to be duplicated and 71 found to not meet study criteria (See also Figure 1.2, Appendix A). Another 53 articles were identified initially in the search of the computer science journals with 1 found to be duplicates and 35 found to not meet study criteria (See also Figure 1.3, Appendix A). Another 3 articles were identified through ancestry searching. None of the health science journals were duplicated in the search of computer science journals.

The final pool of 35 articles was then sorted into three categories of technologies (mobile phone app [n=14], exergame [n=6], and a mobile phone app with physical activity sensor [n=15]) in preparation for ranking according to Melnyk and Fineout-Overholt's (2005) hierarchy of evidence. In the process, it soon became clear that this hierarchy needed to be modified to include three different types of articles: (1) those that described the development of a new technology, mobile phone app, exergame, etc., (2) those that evaluated a particular technology using a one group design, and (3) those that provided expert opinions. This first type of article was common among the computer science journal articles; whereas the latter two were found in both types of articles. The hierarchy was modified by adding the first type of article to the VI category, the second to the IV category, and the third to the VII category (see Figure 1.1, Appendix A).

In the next part of the results, findings for each category of technology will be made summarizing the categories of evidence available. Examples of particular technologies that appear promising will also be included in this description.

Mobile Phone Apps

A total of 14 mobile phone app articles were found. Articles were categorized into levels II, IV, VI, and VII in the hierarchy of evidence. Outcome measures for the only level II article were attitudes towards eating breakfast, likelihood of eating breakfast, and overall healthiness of the breakfast foods eaten (Byrne et al., 2012) . The authors observed effects for attitudes and likelihood of eating breakfast in 12-14 year old boys and girls using an app which provided positive and negative emotional responses from a virtual pet regarding the player’s breakfast food choices.

The outcome measures for the three level IV articles included: attitude towards fitness and exercise with 15-17 year olds (Lu & Turner, 2013); and steps measured with 13 year old girls (Toscos, Faber, Connelly,

& Upoma, 2008). Positive effects were observed on these measures in both studies.

Mobile Phone Apps with Activity Sensors

A total of 15 mobile phone app with activity sensor articles were found in the literature search conducted here (five level IV, three level VI, and seven level VII). Table 2, Appendix B, indicates the outcomes measured for the five level IV articles included: weight loss, Body Mass Index (BMI), physical activity level, duration of physical activity, and dietary intake.

One promising level IV study measured both weight loss and changes in BMI (Schiel, Kaps, & Bieber, 2012). Participants had an overall mean weight reduction of 7.1 ± 3.0 kg over approximately forty-nine days. However, the authors of this article found the self-reported physical activity and dietary intake did not align with the sensor and digital photograph data collected (Schiel, Kaps, & Bieber, 2012). This finding argues for the value of incorporating sensors and digital photograph technologies with Smartphone apps as a means for accurately assessing their health impact.

The level VI and VII articles identified a variety of emerging technologies and apps such as food image analysis (Zhu et al., 2010), physical activity level monitoring with body fat content analysis (Chukwu, 2011), and QR-code reading (Järvinen, Lähteenmäki & Södergård, 2008). These types of technology appear promising in that they facilitate the accurate assessment of fat content (as opposed to just BMI, which does not take muscle and fat content into account) and can be used to calculate dietary intake. Expert recommendations from Garibaldi-Beltran and Vazquez-Briseno (2012) suggest that the several benefits of mobile applications and mobile health for patients with chronic diseases (such as obesity) includes educating, informing, and monitoring for both the patients and the clinicians. In this example, they noted the ability to use Smartphones to educate the patient about their risks, stay informed about choices for their health status, and provide clinicians with self-reported or remotely monitored data over a period of time (Garibaldi-Beltran and Vazquez-Briseno, 2012).

Exergames

A total of 6 exergame articles were found in the literature reviewed. Since the articles consisted of expert advice and observations in school based settings, all the articles were categorized as level VII. Several articles such as Hicks and Higgins (2010) and Wan (2008), made note of the recent use of exergames such as Dance Dance Revolution (DDR) to promote increased physical activity in children especially within school based settings. Other articles discussed the effects exergames may have on improved physical activity and cognitive function (Best, 2013), using head mounted devices (HMD) for children to collaboratively exergame (Maamar, Boukerche, & Petriu, 2012), and two articles examined the role of exergames on mobile phones using GPS technology (Boulos & Yang, 2013; Gorgu, O'Hare, & O'Grady, 2009). Findings suggest that music video/dance rhythm games (MVDG) such as DDR are a form of exergame children enjoy playing and can promote light-moderate physical activity (Best, 2013). Best (2013), suggests that exergames which provide moderate level physical activity have the potential to improve both physical activity and cognitive functioning because increased moderate level physical activity is linked with improved executive functioning. The few articles which focused on DDR as a MVDG were rather promising in that children found them both engaging and motivating (Wan, 2008). Articles regarding the use of GPS technology described how mobile exergames could encourage users to increase physical activity outdoors; however, they also included the possible dangers to users who may accidentaly wander into unsafe or hazardous areas (Boulos & Yang, 2013). Thus, GPS enabled mobile exergames may not be the most appropriate form of exergames for children.

Discussion

Clearly the state of the science with respect to all of the various technologies identified in this literature review is limited. No meta-analyses exist of studies evaluating the impact of technology (i.e., level I evidence in Melnyk & Fineout-Overholt's Hierarchy) and only one RCT (i.e., level II evidence) has been conducted. In sum there is much still which is not known regarding these new technologies and their benefits to health. Nevertheless, this review clearly provides information regarding the advantages and disadvantages of these various health technologies. Hence, this next part of the discussion will summarize the advantages and disadvantages for each category of technology identified in this review.

Mobile Phone Apps

Findings from the literature identified a number of advantages to using mobile phone applications in practice. The prevalence and versatility of mobile phone app use is advantageous for the dissemination of health promoting interventions at a population level. In addition, 85% of adults use mobile phones. Of these users, 35% of adults currently use mobile applications (D'Auria, 2011). Children often use their parent's device for gaming applications and could potentially have access to health promoting applications on their Smartphones. This current percentage of health app users could potentially increase the amount of early adopters for a healthy lifestyle promoting app. In contrast to exergames and physical activity sensors, mobile phone apps are also generally inexpensive with many applications being approximately $\$1.05 \pm 1.66$ (Schoffman, Turner-McGrievy, Jones, & Wilcox, 2013). In addition, app users report enjoying the ease of use, convenience of being on their Smartphone phone (as opposed to traditional paper and pencil food log method; Boushey, 2009), and sharing achievements via social media (Lopes, Silva, Rodrigues, Lloret, & Proenca, 2011). Sharing achievements via social media may also positively influence user outcomes by providing a virtual social support for engaging in healthy lifestyle behaviors (Turner, 2013).

Yet, mobile phone apps currently have two disadvantages as well. Some expert opinions believe that app design for Smartphones poses a data storage challenge due to their limited storage capacity. One potential way around the limited storage capacity could be solved by using the web based server databases such as the iCloud or a similar cloud computing service (Silva, Lopes, Rodrigue, & Ray, 2011). Another shortcoming is the small amount of apps developed specifically for use with children and their parents (Vandewater &Denis, 2011). The literature is clear that family support is an important factor for obesity treatment maintenance in children (Tate et al., 2013).

Mobile Phone Applications with Activity Sensor

The literature reviewed showed some intriguing applications involving the use of physical activity sensors combined with mobile phone tracking. With the recent development of the Nike Fuelband, Fitbit monitor, Jawbone Up, and several other types of activity sensors, children can monitor and track their physical activity level (Valentin & Howard, 2013). These activity sensors provide several prospective advantages to monitoring and tracking physical activity. Generally physical activity sensors are small, unobtrusive, and wearable accessories which are often a bracelet or items that can be attached to athletic shoes. The sensors can not only measure physical activity but also record and track actual physical activity level intensity, heart rate, temperature, sleep pattern, steps taken throughout the day, along with other health related information (Valentin & Howard, 2013). Since these sensors serve as an objective measure of physical activity level, they eliminate the potential discrepancy between self-report data and data associated with accurate level of physical activity intensity (Schiel, Kaps, & Bieber, 2012). In addition, children and teens may find it fun and motivating to know their exact number of steps taken daily or the intensity of their physical activity (Toscos, Faber, Connelly, & Upoma, 2008).

However, there are at least four disadvantages to physical activity sensors. First, while activity sensors measure physical activity, they do not measure the dietary intake of the user. Thus, physical activity for image analysis of food and portion sizes is in development and could be potentially combined with or added to an activity sensor. However, Kong and Tan (2011), note that image analysis technology remains under development and is far away from field development. Secondly, physical activity sensors can be a significant expense for the user, with most costing over a hundred dollars or more. Third, approximately 10,000 users of the Fitbit Force activity sensor have reported skin rashes and irritations which caused Fitbit Force to voluntarily recall the product (Kerr, 2014). Fourth, anecdotal accounts from peers noted that some of these activity sensors are susceptible to breaking. Therefore, further studies and development are required to ensure these activity sensors are safe, reliable, and do not place users at risk for sensitivity reactions.

Exergames

Findings from the literature reviewed here indicate that exergames such as Dance Dance Revolution (DDR) have a number of advantages and are among several forms of music video/dance rhythm games (MVDG) enjoyed by children. Current exergames include a component of fun and can be used for light-to-moderate-intensity activity, which is a greater energy expenditure compared to sedentary gaming (Best, 2013). For families residing in urban environments where there is lack of green space and in climates where outdoor activities are sometimes limited due to weather, exergames can provide a way to get children moving while indoors (Hicks & Higgins, 2010). DDR has been introduced in schools across the United States already including all 765 schools in West Virginia, a state with one of the worst obesity problems in America (Wan, 2008). When considering DDR exergaming in schools, children expressed feelings of anticipation and excitement in playing the games during their physical education classes (Hicks & Higgins, 2010).

However, the literature also identifies three key disadvantages. First, in schools which employed DDR in their physical education classes, some students expressed “getting bored of it” after a few weeks of playing (Wan, 2008). Thus, exergame designers should make these games more varied and goal-reward oriented to motivate continued play and prevent disinterest development over time from increasing predictability. However, findings in the literature also showed that support from friends and family, along with having the ability to exergame with others promotes long-term exergame play (Best, 2013). Second, the use of MVDG among overweight and non-overweight children does not appear to significantly increase heart rate to meet the American College of Sport Medicine standards for developing and maintaining cardiorespiratory fitness (Hicks & Higgins, 2010). Moreover, to date playing such games have not resulted in weight loss for children (Wan, 2008).

Third, game consoles and equipment for DDR software and hardware typically range in price from $300-$400 (Hicks & Higgins, 2010). Although some parents, teachers, and business partners could donate contributions for purchasing MVDG systems, facilitators may still encounter difficulties in funding the technology or users may be hesitant to engage in the activity due to costs.

Limitations

After conducting the literature reviewed here, several limitations were identified. From the beginning of the search, difficulty was encountered in identifying good search terms to clearly find the desired articles involving the use of technological applications for childhood obesity management and prevention. This difficulty in finding articles which met the inclusion criteria could be due to the complexity and multidisciplinary nature of the subject. However, it is unlikely that a better state of the science and more Level I or II evidence exists. The author consulted with a university librarian regarding the use of search terms and effective data base searching as well as with experts in health technology research and development.

Further, Melnyk and Fineout-Overholt's (2005) hierarchy of evidence needed to be adapted to accommodate the types of articles indentified in this review. However, the adaptations made here did not impact the assessment regarding the amount of high quality evidence with which to guide practice. These adaptations only impacted lower levels of evidence, were made in consultation with a nurse researcher, and allowed the use of all the evidence identified.

Implications for Research and Practice

` In general, the literature does not contain strong enough evidence to recommend use of a particular technology over pre-existing interventions with documented efficacy supported by level I or level II research. Nevertheless, there are three clear implications for practice based on the existing state of the science. First, the use of mobile phone apps to track clinical data is advantageous for the clinician. These apps allow clinicians to see a more detailed, long term picture of the patient. Clinicians can view trends of the child's dietary intake and physical activity over time as opposed to individual patient visits where practitioners only see a snapshot of the patient for a single time period. Second, these apps can be used to individualize care and may be useful as an educational tool (patient education) for both children and their parents. Third, it is important for clinicians to review the literature in both the health science and computer science journals to keep abreast of new technological developments because these two databases do not overlap. New technology is evolving rapidly and inevitably the state of the science will move forward given public and professional interest in the use of technology to improve health.

Given the literature reviewed here, there are four clear implications to improve the state of the science. First, there is a great need for additional randomized control trials, one group, and two group studies. Of the articles reviewed, many described a particular mobile app or intervention design, yet few actually conducted a study. In order to make recommendations for practice, levels of evidence ranking as levels I and II are required.

Second, when RCT studies are conducted, quantitative data measures (before, during, and post-intervention) should be emphasized such as weight loss, Body Mass Index (BMI), calories expended, etc. Several of the studies conducted assessed qualitative changes in attitudes and opinions, but few measured weight loss, healthy weight maintenance, or changes in healthy lifestyle behaviors over time.

Third, in relation to recent technological development, further research should be conducted regarding the use of physical activity sensors and image analysis of food and portion size. These tools can be used in combination with mobile apps to provide some of the quantitative measures mentioned above to enhance objective measures and decrease the amount of self-report required by the user. The prices of the activity sensors will most likely decrease in cost over time and these sensors are light, highly compact, and easily wearable. Moreover children appear to find them fun and it provides researchers a way to track physical activity over time. Fourth, a greater number of applications should be specifically designed for and evaluated in the overweight/obese pediatric population (Vandewater &Denis, 2011). It is critical that these applications involve parents as well as children. The literature supports that parent and family involvement in healthy lifestyle and weight loss interventions positively influences outcomes (Tate et al., 2013). In addition, most young children do not have their own Smartphone or similar device and rely on using the mobile device of a parent or family member.

Conclusion

After considering the literature reviewed here, there is undoubtedly a need for more high level research evidence. This research should be conducted and evaluated prior to making definitive evidence based recommendations for practice. Current literature describes many benefits of technological applications such as widespread use, portability, cost-effectiveness, versatility, mobile monitoring, educational resource, information management, and social reinforcement of accomplishments. It appears feasible and appealing for these technological applications to be used in the delivery of healthcare for the management and prevention of childhood obesity. In order to maximize effectiveness of these interventions, there is a great need for the early and continuous involvement of an interdisciplinary team. Ideally the team would include: nursing, medical, computer science, nutrition, physical therapy, athletic training, kinesiology, education, and psychological disciplines. This type of interdisciplinary team would likely generate the most comprehensive and effective technological interventions for the management and prevention of childhood obesity.

APPENDIX A: FIGURES

Figure 1.1 Melnyk and Fineout-Overholt’s (2005) Hierarchy of Evidence, adapted to accommodate the types of evidence identified in this review of the literature

Hierarchy of Evidence for Intervention Studies[2]

Type of evidence	Level of evidence	Description
Systematic review or metaanalysis	I	A synthesis of evidence from all relevant randomized, controlled trials.
Randomized, controlled trial	II	An experiment in which subjects are randomized to a treatment group or control group.
Controlled trial without randomization	III	An experiment in which subjects are nonrandomly assigned to a treatment group or control group.
Case-control or cohort study	IV	Case-control study: a comparison of subjects with a condition (case) with those who don’t have the condition (control) to determine characteristics that might predict the condition. Cohort study: an observation of a group(s) (cohort[s]) to determine the development of an outcome(s) such as a disease.
Systematic review of qualitative or descriptive studies	V	A synthesis of evidence from qualitative or descriptive studies to answer a clinical question.
Qualitative or descriptive study	VI	Qualitative study: gathers data on human behavior to understand *why* and *how* decisions are made. Descriptive study: provides background information on the *what*, *where*, and *when* of a topic of interest.
Opinion or consensus	VII	Authoritative opinion of expert committee.

One group

Emerging technologies and their functionality

Expert

Figure 1.2

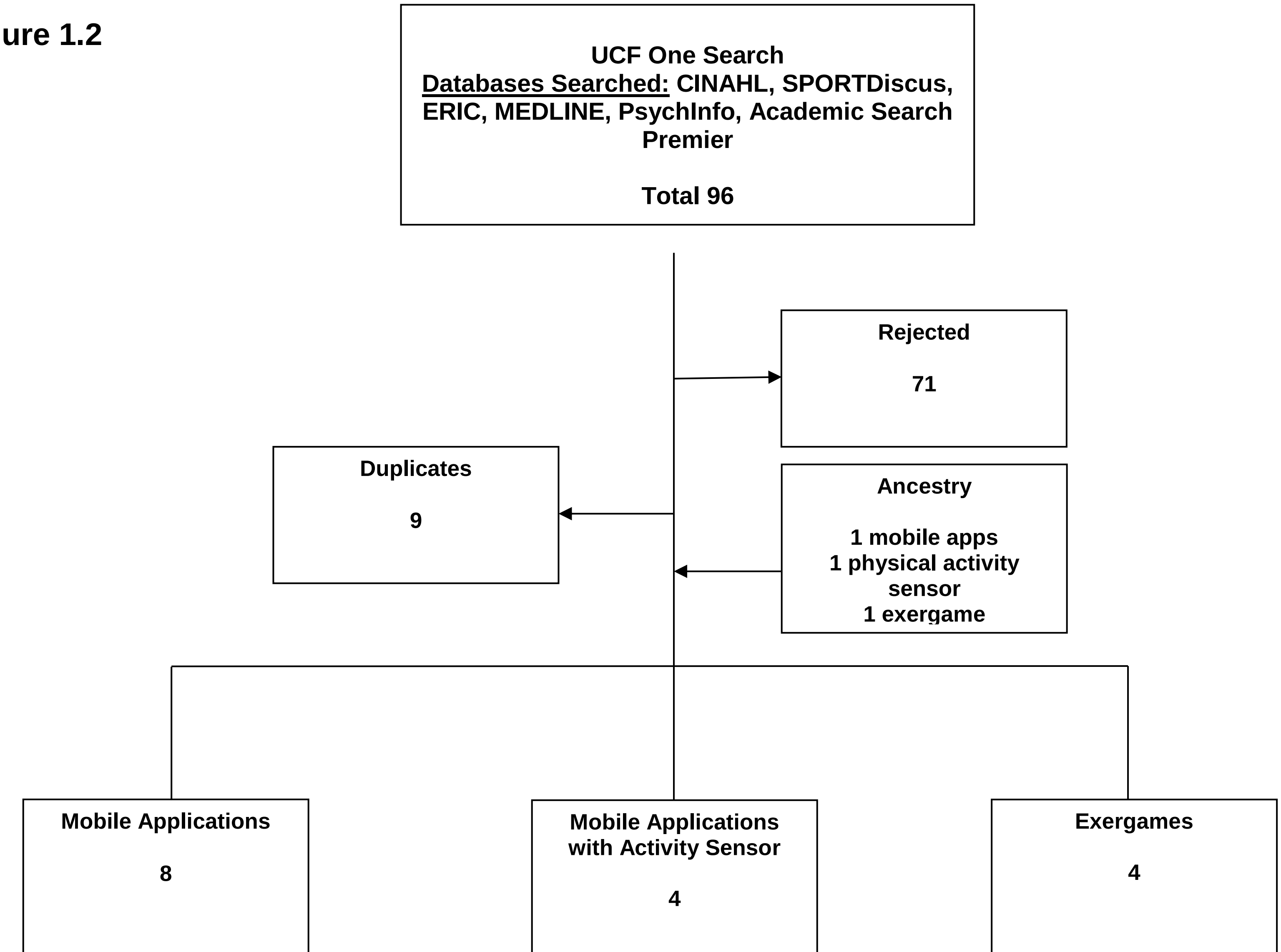
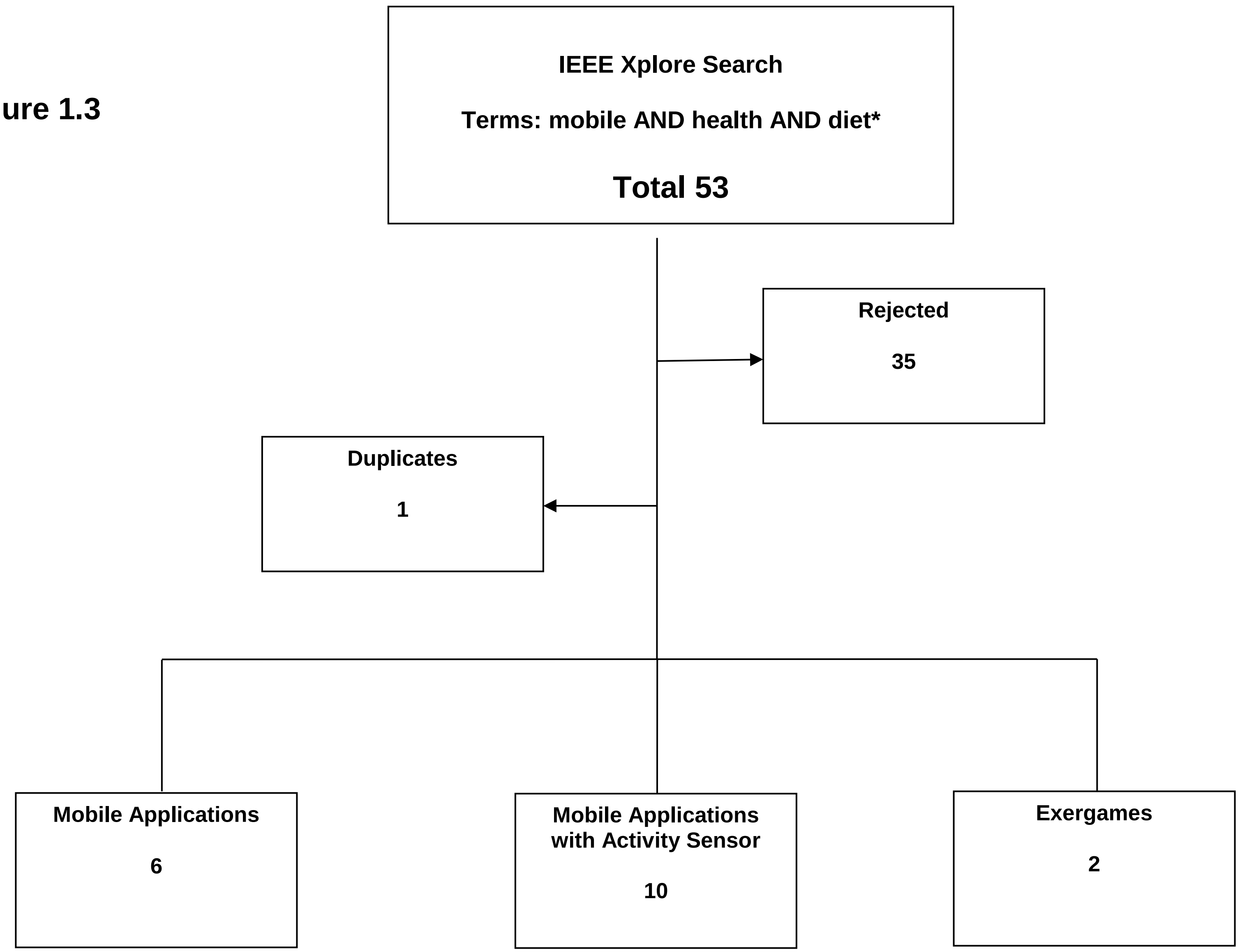

UCF One Search
Databases Searched: CINAHL, SPORTDiscus, ERIC, MEDLINE, PsychInfo, Academic Search Premier
Total 96
Rejected
71
Duplicates
9
Ancestry
1 mobile apps
1 physical activity sensor
1 exergame
Mobile Applications
8
Mobile Applications with Activity Sensor
4
Exergames
4

Figure 1.3


IEEE Xplore Search
Terms: mobile AND health AND diet*
Total 53
Rejected
35
Duplicates
1
Mobile Applications
6
Mobile Applications with Activity Sensor
10
Exergames
2

APPENDIX B: TABLES

Table 1: Mobile Phone Applications

Articles	Evidence Ranking*	Location, Year, Age group	Technology Intervention Details	Length of use	Impact	Other
Byrne, S., Gay, G., Pollack, J., Gonzales, A., Retelny, D., Lee, T., & Wansink, B. (2012) Caring for Mobile Phone-Based Virtual Pets can Influence Youth Eating Behaviors, Journal of Children and Media, 6:1, 83-99, DOI: 10.1080/17482798.2011.633410	II	Northeastern US agricultural community, 2011 12–14 years old	Apple iPhone application with virtual pet. Randomized Control (RCT) trial including three study groups of feedback: positive and negative, positive or neutral only, and the control condition (No-Pet).	9 days	Those who received positive and negative feedback compared to positive only feedback were twice as likely to consume breakfast. Developed more attachment to virtual pets that expressed emotions of happiness and sadness. Attitudes of positive only group scored lower in enjoyment, sustained interest, effort, and skill.	Slightly more males (n= 22) than females (n=17). 84% of the sample was Caucasian, and 16% identified themselves as biracial, mixed race, or other.
Toscos, T., Faber, A., Connelly, K., & Upoma, A. M. (2008). Encouraging physical activity in teens Can technology help reduce barriers to physical activity in adolescent girls? *Pervasive Computing Technologies for Healthcare, 2008. PervasiveHealth 2008,* 218 – 221. Doi: 10.1109/PCTHEALTH.2008.4571073	IV	United States, 2008 13 years old	Pre-paid Nokia N73 mobile phone running the application. Participants given a pedometer and instructions to use. Logged steps taken using pedometer were tracked in the application and web. Users shared step counts to the group and could send encouraging text messages.	21 days	Average step count increased during the second and third weeks after the mobile phone application was introduced. Removal of social support (lack of sharing steps with group) can have adverse effect on use of technology and increased steps taken.	Three groups of girls were already "best friends." If competition taken too far it could cause bad feelings or behavior (participant commented). Intimacy of small group reported as a benefit.

Lu, F., & Turner, K. (2013) Improving Adolescent Fitness Attitudes with a Mobile Fitness Game to Combat Obesity in Youth, ***Games Innovation Conference (IGIC), 2013 IEEE International**,* 148-151. Doi: **10.1109/IGIC.2013.6659162**	IV	Canada, 2013 15-17 years old	4th generation iPod touch with UOIFit application. Participants were given an iPod sports armband to hold the device while performing application exercises. Exercise performed during class time. Social network sharing enabled.	42 days	Twitter application demonstrated the strongest correlation with improved attitudes towards fitness exercises. Sample size of 12, degrees of freedom 10. 95% significance level r ≥ 0.58, only the sit-ups considered significant	Comparison of pre-study and post-study views showed participants felt more comfortable performing exercises post-intervention.
Silva, B.M., **Lopes, I.M.**, **Rodrigues, J.J.P.C.**, & **Ray, P.** (2011) SapoFitness: A mobile health application for dietary evaluation, ***e-Health Networking Applications and Services (Healthcom), 2011 13th IEEE International Conference***, 375-380, **10.1109/HEALTH.2011.6026782**	IV	Portugal, 2011 Age unknown	Presents SapoFitness and discusses the use of mobile phone tracking for electronic health records (EHR).	Several weeks	System was evaluated by users and general feedback was good. Users did not feel obliged to use the app and found it fun. Researchers note d that this creates a positive and motivating relationship.	
Lopes, I.M. Silva, B.M., **Rodrigues, J.J.P.C.**, Lloret, J., & Proenca, M. (2011) A mobile health monitoring solution for weight control, Wireless Communications and	VI	Portugal, 2011	Presents SapoFitness for continuous monitoring and tracking physical activity level and diet.	Not applicable	This application is designed for Android operating system and is ready for use. Designers suggest the app is motivating for users to lose weight and exercise due to the ability to share achievements with others on social networking sites.	

Signal Processing (WCSP), 2011 International Conference, 1-5, **10.1109/WCSP.2011.6096926**						
Hsu, H., Chang, M., & Yen, N.Y. (2012) A health management application with QR-Code input and rule inference. *Information Security and Intelligence Control (ISIC), 2012 International Conference on,* vol., no., pp119-122, 14-16 Aug. 2012	VI	Taiwan, 2012	Discusses the use of QR code reading for dietary monitoring.	Not applicable	This form of mobile application can be used to track dietary intake and self-reported physical activity. The application can be individualized for normal users, users with specific diseases, and users who want to lose weight.	
Tate, E., Spruijt-Metz, D., O'Reilly, G., Jordan-Marsh, M., Gotsis, M., Pentz, M., & Dunton, G. (2013). mHealth approaches to child obesity prevention: successes, unique challenges, and next directions. *Translational Behavioral Medicine*, *3*(4), 406-415. doi:10.1007/s13142-013-0222-3	VII	California, 2013	Discusses the use of mobile health (mHealth) technology in regards to advantages and challenges.	Not applicable	Advantages to mHealth include: continuous monitoring, cost effective dissemination, real time data collection, lower participant burden, and ability to individualize. Challenges include: slow speed of scientific development/ implementation compared to other mobile technology, difficulty with coordinating a multidisciplinary team, data transfer, privacy issues, and implementation with children and families.	
Schoffman, D., Turner-McGrievy, G., Jones, S., & Wilcox, S. (2013). Mobile apps for pediatric obesity prevention and treatment, healthy eating,	VII	South Carolina, 2013	Reviewed healthy eating and fitness mobile applications available in iTunes.	Not applicable	61.4% did not use any of the recommended strategies or behavior targets for weight loss. Apps that were recommended included HyperAnt and Smash	

and physical activity promotion: just fun and games?. *Translational Behavioral Medicine*, *3*(3), 320-325. doi:10.1007/s13142-013-0206-3					Your Food.	
D'Auria, J. (2011). Weighing in: prevention of childhood overweight and obesity. *Journal Of Pediatric Health Care: Official Publication Of National Association Of Pediatric Nurse Associates & Practitioners*, *25*(6), e26-e30. doi:10.1016/j.pedhc.2011.07.011	VII	North Carolina, 2011	Reviews healthy eating and fitness promoting applications and websites.	Not applicable	Reports that previous findings regarding self-monitoring of dietary intake on a mobile device can change behavior.	
Vandewater, E., & Denis, L. (2011). Media, social networking, and pediatric obesity. *Pediatric Clinics Of North America*, *58*(6), 1509-1519.	VII	Texas, 2011	Examines the history of social media and technology in relation to childhood obesity.	Not applicable	Notes the potential to use media and technology in the promotion of healthy lifestyle behaviors in children. Discusses the need for more app development in children. Reports previous research which found associations between the use of media and technology among children, although consistently positive, are weak, and concluded that they are of little clinical relevance.	
Tate, D. F. (2008). Application of innovative technologies in the prevention and treatment	VII	North Carolina, 2008	Discusses use of technology for behavior change.	Not applicable	Discusses how technology use in the treatment and management of childhood obesity is promising.	

of overweight in children and adolescents. In E. Jelalian, R. G. Steele (Eds.) , *Handbook of childhood and adolescent obesity* (pp. 378-404). New York, NY US: Springer Science + Business Media.						
Yusof, A.F., & Iahad, N.A.(2012) Review on online and mobile weight loss management system for overcoming obesity, vol., no., pp 198-203, 12-14 June 2012	VII	2012	Reviews previous technological interventions for obesity.	Not applicable	Previous research supports that self-monitoring is the best applied practice for weight loss management.	
Ip, M. (2010). Good reception -- kids receive healthy messages through interactive technologies. *Today's Dietitian*, *12*(7)	VII	Pennsylvania, 2010	Discusses the use of technologies to provide children with positive feedback for healthy behaviors.	Not applicable	Notes the use of technology to promote healthy lifestyle behaviors and give children positive messages.	
Clarke, P., & Evans, S. H. (2013). Fighting Obesity among Low-Income 9-14 Year Olds: A Home-based Intervention Using Mobile Phones to Deliver Customized Nutrition Outreach. *Journal Of Nutrition Education & Behavior*, *45*(4S), S79.	II (to be)	California, 2013	Discusses the use of mobile phones to promote increased consumption of fruits and vegetables in low socioeconomic families.	Six months	Research is forthcoming. RCT in families to use a diet and meal planning mobile application to encourage the incorporation of fruits and vegetables in to thei diet.	

Table 2: Mobile Phone with Physical Activity Sensor and/or Physical Activity Survey and/or Mobile Phone with Pictures or Image Analysis of Dietary Intake

Articles	Evidence Ranking*	Location, Year, Age group	Technology Intervention Details	Length of use	Impact	Other
Schiel, R., Kaps, A., & Bieber, G. (2012). Electronic Health Technology for the Assessment of Physical Activity and Eating Habits in Children and Adolescents with Overweight and Obesity IDA. *Appetite*, *58*(2), 432-437. doi:10.1016/j.appet.2011.11.021	IV	Germany, 2011 13.5 ± 2.8 years old	Dietary intake and physical activity was tracked using a mobile phone with a mobile motion sensor (MoSeBo) and a digital camera (DiaTrace).	36.5 ± 13 days	Discrepancy between reported dietary intake and physical activity compared to their photographs and activity sensed. Participant's mean weight reduction was 7.1 ± 3.0 kg. BMI and BMI-SDS decreased from 31.3 ± 5.2 kg/m^2 and 2.50 ± 0.50 to 28.7 ± 4.9 kg/m^2 ($p < 0.01$) and 2.15 ± 0.57 ($p < 0.01$).	
Schiel, R., Kaps, A., Bieber, G., Kramer, G., Seebach, H., & Hoffmeyer, A. (2010). Identification of determinants for weight reduction in overweight and obese children and adolescents. *Journal Of Telemedicine And Telecare*, *16*(7), 368-373. doi:10.1258/jtt.2010.091005	IV	England, 2010	MoSeBo and a DiaTrace technology used to monitor the mean intensity of the participants' physical activity.	4 days	Discrepancy between reported physical activity compared to activity sensed. Researchers found the real caloric intake of the children and adolescents was higher than self-reported data.	
Dunton, G. F., Yue, L.,	IV	California, 2010	Surveyed through	4 days	The participants' activity	Participants felt

Intille, S. S., Spruijt-Metz, D., & Pentz, M. (2011). Investigating Children's Physical Activity and Sedentary Behavior Using Ecological Momentary Assessment With Mobile Phones. *Obesity (19307381)*, *19*(6), 1205-1212.		9-13 years old	Ecological Momentary Assessment (EMA) using mobile phone. The Actigraph, GT2M activity monitor objectively measured their physical activity.		interfered with EMA. Feasible in youth as young as 9 years old.	the device was easy to use and unobstructive.
Boushey, C. J., et al. "Use of technology in children's dietary assessment." *European Journal of Clinical Nutrition* 63, (February 2, 2009): S50-S57. *Academic Search Premier*, EBSCO*host*	IV	Indiana, 2007 11-15 years old	Six approaches of measuring dietary intake were used (two technology based). The two technologies based used mobile phone PDAs one with a hierarchical menu and one with a camera.	~9 days of technology based intervention	Reported traditional methods of food records (FR) and 24 hour recall (24HR) were "a hassle, boring, and tedious." The PDA method was preferred compared to the 24HR. Use of a camera was described as "lot easier and fun."	Participants were 16 boys and 15 girls of Chinese heritage. Resided in campus residence hall where all meals and snacks were provided. Strong preference for methods incorporating technology. Difficult to generalize to main population
Zhu, F., Bosch, M. ; Boushey, C.J., &	IV	Indiana, 2010	The article focuses on the development of an	Not applicable	Researchers conducted experimental trials in which participants took pictures of their	

Delp, E.J. (2010) An image analysis system for dietary assessment and evaluation. *Image Processing (ICIP), 2010 17th IEEE International Conference on,* vol., no., pp. 1853 – 1856, 26-29 Sept. 2010			image analysis system to measure the amount of food in the image.		food. They image s were segmented to estimate portion size and food items. The accuracy of their results ranged from 88.1-97.2%.	
Ali, S.T., Sivaraman, V., Ostry, D.(2012) Authentication of lossy data in body-sensor networks for healthcare monitoring. *Sensor, Mesh and Ad Hoc Communications and Networks (SECON), 2012 9th Annual IEEE Communications Society Conference on,* vol., no., pp 470-478, 18-21 June 2012	VI	Austrailia, 2012	Describes new technology of a wearable medical monitoring device.	Not applicable	Sensors can serve as a low cost and practical solution for medical monitoring.	
Kong, F., & Tan, J. (2011) DietCam: Regular Shape Food Recognition with a Camera Phone. *Body Sensor Networks (BSN), 2011 International Conference on,* vol., no., pp 127-132, 23-25 May 2011	VI	United States, 2011	Discusses the use of Dietcam technology for tracking dietary intake.	Not applicable	Traditional methods of diet record relying on individual self-recording often have low accuracy and high dependence on the user. Using a Dietcam and related technologies has the potential to accurately identify and record food items and portion size.	Authors note that this technology remains under development and is far away from field development.
Jarvinen, P., Jarvinen, T.H., Lahteenmaki, L., & Sodergard, C. (2008) HyperFit: Hybrid media in	VI	Finland, 2008	Technology described involves use of internet and mobile application	Not applicable	Application technology can be individualized to the patient. This example includes having a virtual trainer who encourages	

personal nutrition and exercise management. *Pervasive Computing Technologies for Healthcare, 2008. PervasiveHealth 2008. Second International Conference on,* vol., no., pp 222-226, Jan. 30 2008-Feb. 1 2008			tracking and monitoring.		the user's physical activity and nutrition.	
Zhu , F., Bosch, M., Woo, I., & Kim, S. (2010) The Use of Mobile Devices in Aiding Dietary Assessment and Evaluation. *The Journal of Selected Topics in Signal Processing,* 4(4), 756-766. doi: 10.1109/JSTSP.2010.2051471	VII	Indiana, 2010	Discussed the use of new technology related to image analysis in calculating consumed food.	Not applicable	The article includes various methods of recording dietary intake such as 24 hour recall, food record, and portion size estimate. With recent technology, image analysis can capture and identify foods in a single image on a mobile phone, thus making it easier for the user.	Authors suggest mobile phone use in adolescents may improve cooperation and accuracy.
Chukwu, M. (2011) Personalized mobile monitor for assisted healthy-living. *Consumer Communications and Networking Conference (CCNC), 2011 IEEE,* vol., no., pp.18-22, 9-12 Jan. 2011	VII	Canada, 2011	Discusses a non-invasive device which would measure physical activity and body fat content.	Not applicable	Technology provides an objective measure of body fat content and physical activity which can help users maintain a healthy lifestyle.	
Garibaldi-Beltran, J.A. , & Vazquez-Briseno, M. (2012) Personal Mobile Health Systems for Supporting Patients with	VII	California, 2012	Article discusses the use of mobile devices for education, information, and monitoring for	Not applicable	Explains the components of Personal Mobile Health Systems (PMHS) including: user, sensor, mobile device, mobile network, and terminal (healthcare worker accesses records of the users).	

Chronic Diseases. *Electronics, Robotics and Automotive Mechanics Conference (CERMA), 2012 IEEE Ninth,* vol., no., pp. 105-110, 19-23 Nov. 2012			patients with chronic diseases.		This form of technology has the potential to improve healthcare delivery and effectiveness.	
Shang, J., Duong, M., Pepin, E., Zhang, X., Sandara-Rajan, K., Mamishev, A., & Kristal, A.(2011) A mobile structured light system for food volume estimation. *Computer Vision Workshops (ICCV Workshops), 2011 IEEE International Conference on,* vol., no., pp. 100-101, 6-13 Nov. 2011	VII	United States, 2011	Consists of a mobile Smartphone and a laser attachment. The laser attachment uses grid technology to evaluate portion size.	Not applicable	This technology remains under development, but has the potential to assist users in estimating portion size and food volume.	
Khanna, N. Boushey, C.J., Kerr, D., Okos, M. , Ebert, D.S., & Delp, E.J. (2010) An Overview of the Technology Assisted Dietary Assessment Project at Purdue University. *Multimedia (ISM), 2010 IEEE International Symposium on,* vol., no., pp 290-295, 13-15 Dec. 2010	VII	Indiana, 2010	The article discusses the development of an image analysis system to measure the amount of food in the image.	Not applicable	The authors note the importance of measuring accurate dietary intake which. This is considered to be an open research problem in both the nutrition and health science fields.	
He, Y., Khanna, N., Boushey, C.J., & Delp, E.J. (2013) Image segmentation for image-	VII	Indiana, 2013	Describes technology related to food segmentation to	Not applicable	This article discusses the importance in regards to the link between diet and health. The technology uses a mobile phone	Six of the ten leading causes of death in the United States

based dietary assessment: A comparative study. *Signals, Circuits and Systems (ISSCS), 2013 International Symposium on,* vol., no., pp 1-4, 11-12 July 2013			identify food items and estimate portion size.		with a built in camera to determine the food and portion size by taking pictures before and after the meal.	can be linked directly to diet.
Spring, B., Gotsis, M., Paiva, A., & Spruijt-Metz, D.(2013) Healthy Apps: Mobile Devices for Continuous Monitoring and Intervention. *Pulse, IEEE* , 4(6), 34-40. doi: 10.1109/MPUL.2013.2279620	VII	Chicago, 2013	Discusses the need for health behavior change with the use of technology.	Not applicable	Technological applications can be beneficial for monitoring, motivating, and modifying behaviors.	

Table 3: Exergames

Articles	Evidence Ranking*	Location, Year, Age group	Technology Intervention Details	Length of use	Impact	Other
Hicks, L., & Higgins, J. (2010). Exergaming: Syncing Physical Activity and Learning. *Strategies: A Journal For Physical And Sport Educators*, *24*(1), 18-21.	VII	United States, 2010 Game appropriate for children aged five years and older	Review article of music video/dance rhythm game (MVDG), Dance Dance Revolution (DDR) as a school based intervention for increased physical activity.	Not applicable	May be able to reach groups traditionally less interested in physical education. Increases heart rate but does not meet recommended standards for cardiorespiratory fitness.	Built-in workout mode allows player to track calories burned. Alternative for buying all expensive simulation pads is to use carpet samples for practice pads.
Best, J. R. (2013). Exergaming in youth: Effects on physical and cognitive health. *Zeitschrift Für Psychologie*, *221*(2), 72-78. doi:10.1027/2151-2604/a000137	VII	St. Louis, Missouri, United States, 2013 Children	Review article which examined exergaming as a viable intervention to increase physical activity and cognitive function in youth.	Not applicable	Evidence shows exergames promote increased light-moderate-intensity physical activity but do not have energy expenditure equal to that of moderate-vigorous physical activity.	Some games reviewed had a greater energy expenditure compared to treadmill walking.
Kamel Boulos, M. N., & Yang, S. P. (2013). Exergames for health and fitness: the roles of GPS and geosocial apps. *International Journal Of Health Geographics*, *12*(1), 1-7. doi:10.1186/1476-072X-12-18	VII	United Kingdom, 2013	Review article of GPS exergames and geosocial apps and gadgets.	Not applicable	GPS enabled exergames have the ability to promote users to engage in mobile gaming outdoors. Activities such as geocatching are a good example of modern “treasure hunting” that allows users to compete for hidden treasures and explore the outdoors.	Authors comment that the users may encounter problems with location privacy, malware, and the risk of wandering into hazardous

						areas.
Wan, K. (2008). Exercise is revolting. *Journal Of The Royal Society For The Promotion Of Health*, *128*(1), 12-13.	VII	United Kingdom, 2008	Discussion article regarding the impact and potential for exergames.	Not applicable	Exergames such as Dance Dance Revolution provide an opportunity for children traditionally less interested in competitive sports teams to engage in physical activity.	These games can “act as a bridge” between the exergame and traditional sports like football.
Maamar, H.R., Boukerche, A. , & Petriu, E.M. (2012) 3-D Streaming Supplying Partner Protocols for Mobile Collaborative Exergaming for Health. *IEEE Journal of Biomedical and Health Informatics.*16(6), 1079 – 1095. doi: 10.1109/TITB.2012.2206116	VII	Canada, 2012	Discussion about the development of new technologies such as Head Mounted Devices (HMD) which can be used to assist children in exergaming collaboratively.	Not applicable	Children can use these devices to correspond their activity level to that of a virtual avatar. With these types of devices, participants can collaborate and compete against each other in interactive gaming.	Authors note the current importance of exergames to combat childhood obesity and how the social component likely enhances effectiveness.
Gorgu, L., O'Hare, G.M.P., & O'Grady, M.J. (2009) Towards Mobile Collaborative Exergaming. *Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services Second International Conference on,* vol., no., pp.61-64, 20-25 Sept. 2009	VII	Ireland, 2009	Discussion of the Lutfen mobile exergame which encourages users to move between zones outdoors.	Not applicable	Exergames should be designed and personalized for the individual.	Social component which allows players to collaborate seems beneficial.

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