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The Effects of Wearable Fitness Devices on Pediatric Obesity: An Integrative Literature Review

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THE EFFECTS OF WEARABLE FITNESS DEVICES ON PEDIATRIC OBESITY: AN INTEGRATIVE LITERATURE REVIEW

by

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ABSTRACT

Childhood obesity is a foremost concern throughout the health care community. Approximately 17.6% of the pediatric population meet the criteria for obesity, which can lead to health disparities later in life, such as hypertension, type 2 diabetes mellitus, and metabolic syndrome. Emerging mobile and wearable lifestyle tracking devices can be a viable solution to the challenging problem of childhood obesity through behavior changes, feasibility, and adherence. The purpose of this literature review was to determine the effect that mobile and wearable activity tracking devices have on the obese pediatric population. A centralized review of the literature was conducted using various data bases and resulted in 19 articles. 5 articles were chosen to review in more detail. 13 other articles were hand searched through credible resource citations, rendering 14 articles that met all criteria. The three general themes found in this literature review suggest that wearable activity tracking devices can be designed and effectively used by the pediatric population. Also, wearable activity tracking devices are accurate in conveying information on physical activity, calories, and heart rate. Lastly, wearable activity tracking devices can initiate behavioral changes in children leading to an increase in physical activity, resulting in the prevention and treatment of pediatric obesity. While in a majority of the studies analyzed trails were short. The research suggests wearable activity tracking devices will produce the desired results of increased activity in pediatric populations when they are worn correctly, are adequately engaging, and when they are designed in a feasible manner that is appealing to children.

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INTRODUCTION

Obesity is of paramount concern across the healthcare community. In the last several decades there has been a significant increase in obesity amongst the general population in the United States. Although adult weight gain is problematic, childhood obesity can lead to a lifetime of health concerns and complications (Bennett, Sothern, Bennett, & Sothern, 2009). Obesity in children has been correlated to the development of cardiovascular and metabolic diseases in adulthood (Vissers, Hens, Hansen, & Taeymans, 2016). Health related complications due to obesity at a young age are not limited solely to physiological problems; obesity also increases the prevalence of psychological disorders in children such as; low self-esteem and depression (Bennett et al., 2009). Among children ages six through 11, up to 17% meet the criteria for a diagnosis of obesity. In the 1980's obesity in adolescents ages 12 through 19 was present in about 5% of the United States. Unfortunately, as of 2006 the prevalence of obesity in the 12 through 19-year-old population has increased to 17.6% (Bennett et al., 2009). The increased prevalence of obesity in younger populations is thought to be influenced by lack of daily physical activity associated with sedentary life styles and an increased number of hours spent using technology such as watching television and playing video games (Bennett et al., 2009). Although, technology has shown to be a reason for a more sedentary lifestyle, it has also shown to be of great use in the expenditure of energy in children (Bennett et al., 2009).

Wearable technology has become a popular and hopeful intervention that guides users and encourages an increase level of physical activity (Mercer, Li, Giangregorio, Burns, & Grindrod, 2016). A possible solution to this problem is adequate physical activity, as it has shown to be a key component in the prevention of pediatric obesity (Schaefer et al., 2015). Research suggests that

children and adolescents are more likely to increase their levels of physical activity throughout the day due to wearable activity trackers (Mercer et al., 2016). In addition, evidence suggests that behavioral changing techniques used by mobile fitness apps and trackers may reduce the prevalence of pediatric obesity (Nguyen, Kornman, & Baur, 2011).

BACKGROUND

Activity Tracking Applications

Smart phone fitness applications have been shown to motivate wearers to make lifestyle changes and increase physical activity (Conroy, Yang, & Maher, 2014). There are four main behavior/motivation techniques that are used by the developers of these applications; 1) instructing the user how to execute the exercise, 2) demonstrate how to execute the exercise, 3) evaluating performance and giving motivating feedback, and 4) creating goals (Conroy et al., 2014). These applications are used to sync the data wearable tracking devices record and view the progression of physical activity. The ability to download fitness records may assist healthcare providers with identifying active lifestyle patterns and facilitating changes to plans of care. Furthermore, parents may look at this information and identify changes the family can make together such as limiting screen time to the recommended two hours daily (Bennett et al., 2009).

Self-efficacy

The motivational success of fitness trackers is based on the theory of self-efficacy (Mercer et al., 2016). Self-efficacy is known as what people believe they are capable of doing is based on certain events that affect their lives. Self-efficacy is the reason why people think the way they think, feel the way they feel, behave in certain ways, and find specific motives (Bandura, 1994). Efficacy is achieved through several different methods. The most effective way to achieve a strong sense of efficacy is through overcoming difficult, vigorous experiences; such as failure, setbacks, and lack of achievement in goals or experiences. Once challenging obstacles have been overcome people get the sense they have what it takes to achieve anything because they have faced hardship and suffering (Bandura, 1994). Social persuasion is another method and the most common method

seen when using mobile application or wearable technology. A persuasive approach tries to convince people they have the ability to overcome anything (e.g. hardship, lost, failure, suffering). Persuasive tactics can lead people to put forth an increased amount of effort and tend to keep the positive mindset, that they can do it rather than giving in to self-doubt when faced with a difficult situation (Bandura, 1994).

American Academy of Pediatrics

The American Academy of Pediatrics recognizes that pediatric obesity is a public health priority. Furthermore, encourages both the individual and the parents to follow a healthier lifestyle (Hassink, 2015). For instance, Dr. Sandra Hassink suggests buying fewer sugary beverages, high calorie snacks, and reducing the amount of sedentary behavior such as television and other media (Hassink, 2015). Lastly, the American Academy of Pediatric recommends that children participate in sixty minutes of physical activity (Hassink, 2015).

Barriers

Children of all ages are faced with several barriers when wearing physical activity trackers. Adolescents often have a limited scope of understanding how their health choices will affect them as adults, which is a key component in understanding why using a physical activity tracker is important and what consequences are associated with pediatric obesity. Studies suggest that adolescent students lack the knowledge of eating healthy and exercising (Gray, Klein, Noyce, Sesselberg, & Cantrill, 2005).

Second, feasibility of wearing trackers, adhering to the application, and tracking physical health. Data suggest there is a low level of engagement in wearable activity trackers in adolescents that continues to decrease over time. Low levels of engagement for the use of wearable activity

trackers in obese adolescents can limit using the trackers to their fullest potential, such as monitoring caloric intake, use of food journals, and daily accountability for physical activity. Environmental factors and motivation are the two main barriers seen leading to a lack or decreased amount of regular engagement (Schaefer, Ching, Breen, & German, 2016).

Summary

Childhood obesity has also been associated with long term effects on a child's physiological state. Obesity can lead to an elevated risk for obtaining the vast majority of chronic health conditions and diseases such as; asthma, sleep apnea, bone and joint disorders (e.g. arthritis, torn meniscus, and epicondylitis), increased risk for heart disease, and Metabolic syndrome. Metabolic syndrome is a combination of risk factors characterized by hypercholesterolemia, hypertension, hyperglycemia, and increased waist circumference that can lead to the development of type 2 diabetes, stroke, and cardiovascular diseases (Center for Disease Control and Prevention, 2017). While obesity may have a substantial effect on the physiology of the human body it is not limited to this only. Obesity has been associated with psychological alteration in children. For instance, social isolation, depression, and a decreased level of self-esteem (Bennett et al., 2009).

The solution to encouraging the pediatric population to be more compliant with wearable technology is; 1) support from trained a personnel, 2) teaching users the proper way of using these trackers can increase continuous use (Schaefer et al., 2016). 3) targeting specific age groups, evidence shows adolescents are more engaged with the use of G.P.S, Music, and video (Lu & Welton, 2012). 4) having the tracker be wrist worn as opposed to hip, 5) water proof casing, 6) comfortable to wear and proper fitting, 7) and lastly, include engaging features in the mobile application (Schaefer, Van Loan, & German, 2014) (Fairclough et al., 2016).

PROBLEM

The increase of obesity in the pediatric population in the past thirty years has been correlated with the lack of daily physical activity seen in children and adolescents (Bennett et al., 2009). The recommended sixty minutes of daily activity in children is imperative for the prevention and/or treatment of obesity in the pediatric population (Hassink, 2015). Therefore, one way this is possible is through mobile and wireless wearable technology. Evidence shows that mobile and wireless wearable technology is a practical and adequate option for measuring, promoting, motivating, and recording physical activity in the pediatric population, leading to the prevention of obesity in preadolescents and adolescents (Turner, Spruijt-Metz, Wen, & Hingle, 2015).

PURPOSE

The Purpose for this literature review is to determine if mobile and wearable activity tracking devices influence the reduction of weight in the obese pediatric population. The prevalence of preadolescent and adolescent obesity is of immense concern (Bennett et al., 2009). The problem resides with the lack of implementation and enforcement of physical activity (Bennett et al., 2009). Studies have shown that exercise has a positive effect in the reduction of adipose tissue in preadolescents and adolescents. However, in high schools, there is a reported attendance of 51.6% for classes that involve physical activity per week, such as Physical education and weight training. While an alarming 29.8% of the students confirm going to classes which involve physical activity on a daily basis (Center for Disease Control and Prevention, 2017). Studies have been conducted and suggest that the pediatric population should get a recommended 60 minutes of physical activity per day. Unfortunately, only 21.6% of the pediatric population, ages 6 to 19 years of age report actually meeting this recommendation for 5 days out of the week (Center for Disease Control and Prevention, 2017). Compared to intervention like dieting, physical activity is significantly greater at reducing fat (Vissers et al., 2016). Therefore, wearable activity tracking devices may aid adolescents in building habitual tendency, motivate them to meet or even surpass goals, and become more engaged in physical education through the use of wearable tracking devices and exergames (Lindberg, Seo, & Laine, 2016).

METHODS

A centralized review of the literature was conducted on the effects wearable fitness devices have on pediatric obesity, using the following data bases: Cumulative Index to Nursing and Allied Health Literature (CINAHL), Educational Resources Information Center (ERIC), Elton B. Stephens Co. Host (Ebsco Host), Medical Literature On-line (Medline), Psychological Information (PsychINFO), and Sport Discussion Database (SPORTDiscus). Search criteria was limited to peer-reviewed articles published from 2006 to 2017 that were written in the English language. The initial search revealed 19 articles using key terms alone and in combination, Childhood*, Pediatric*, Wearable technology*, and Obesity*. Five articles were selected for further reviewing from the initial search. Articles were evaluated for relevance to the topic, which included 1) Mobile and wearable technology used to track daily activity, 2) Effects wearable technology have on obesity, and 3) Feasibility amongst the adolescent population. Studies were delicately evaluated for crucial information on obesity, as well as, technology. Excluded articles contained information on computer trackers (e.g. MyPlate.com), adult obesity, and elderly obesity (e.g. ages greater than 18). Two of the five articles met all criteria, which have been included in this literature review. An additional search was conducted using key terms kids*, teenagers*, Adolescents*, pediatric*, childhood*, obesity*, overweight*, wearable technology*, wearable fitness trackers*. From this search 13 articles were selected to be included in the literature. A total of 14 articles have been included in the literature review.

RESULTS

The fourteen articles analyzed for further relevance to wearable fitness trackers in reducing childhood obesity identified several key indicators for use and activity outcomes. First, the design of wearable fitness devices and whether or not they are geared towards the pediatric population. Second, the accuracy of wearable fitness devices on physical activity in children. Third, the use of behavioral change techniques and their effectiveness.

Design and Adherence

Out of the fourteen articles included in this literature review eight concentrated on design and adherence to the pediatric population ages 6 through 19. Several studies and trials were conducted using different age groups which included age 14 – 16, 7 – 10, and 6 – 19. Several fitness tracking devices were also used to compare, and contrast adherence based on personalization, orientation, durability, adjustability, and engaging features. The eight articles focused on design and adherence of wearable fitness trackers in children suggest the pediatric population would be more engaged or inclined to wear a fitness tracking device if it gave them the ability to personalize their device such as different casings, multiple watch faces, and a choice of wrist bands. The studies also found that wrist worn devices are more desirable to the pediatric population than an ankle worn, or hip worn device. Durability was also found to play a major role in adhering to the pediatric population. In several studies children decided not to wear their device everyday due to the fear of breaking it. One study by Sara E. Schaefer, found that a device that is comfy, fits well, has engaging aspects, and is water proof has a higher feasibility and compliance level in children (Schaefer et al., 2014). Lastly, engaging features such as exercise games, feasible

mobile application, awards, and incentives showed not just adherence to wearing a device but also, an increased physical activity level in children.

Accuracy

In three of the fourteen studies that were included in this literature review accuracy of wearable fitness tracker devices was a primary concern and to determine if wearable fitness tracking devices are a reliable and accurate source of data for physical activity in children. The articles examined behaviors in children and adolescents ages 6 through 19. All three articles found that wearable fitness tracking devices are a reliable and accurate source of information when tracking physical activity in children. The first of three articles that focused on accuracy and suggested that six days of data retrieved from the pedometers used in the study providedadequate reliability for research and resulted in habitual physical activity (Rxx = .79) (Rowe, Mahar, Raedeke, & Lore, 2004). The second article found that a full week of data provided the most accurate and reliable amount of days to measures someone's activity due to the daily variation in routine (Rowlands, 2007). Lastly the third article found that having children use pedometers for seven days and only removing them for showering and swimming, gave a good estimate as to the total amount of physical activity children and adolescents should be participating in daily (Wolff-Hughes, Bassett, & Fitzhugh, 2014).

Behavioral Change Techniques

Three articles out of the fourteen focused specifically on behavioral change techniques used in mobile and wearable fitness tracking devices and how they effective physical activity in children. One of the articles on behavioral change techniques was a systematic review on which behavioral change technique is the most effective in changing physical activity and eating

behaviors. The systematic review was divided into two individual categories (1) obesity management and (2) obesity prevention. Results suggested that 6 out of the 9 (67%) articles show effective behavioral changing techniques (BCT) in childhood obesity management. For obesity prevention there were four articles that suggested effective BCT's while another four articles suggested no change (50%). The techniques found to be effective in obesity management provided insightful information on consequences of behavior to the individual, environmental restructuring, stress management/emotional control training, prompt identification as role model/position advocate, general communication skills training, and prompt practice (Martin, Chater, & Lorencatto, 2013). Through the use of BCT's, other studies have found children being more engaged in physical activity. For instance, through exercise games and the use of behavioral change techniques such as environmental restructuring and practice children heart and physical activity increased according to Renny Lindberg (Lindberg et al., 2016). Lastly one of the three articles on behavioral change techniques found the use positive feedback reinforcing goal attainments are valued, whereas negative comments or messages are demotivating. However, the same study found that participants did not show a significant desire to alter their exercise behaviors. However, rated themselves highly during baseline suggesting that their exercise behavioral changes had already taken place (Edwards, McDonald, Zhao, & Humphries, 2014).

LIMITATIONS

Several limitations were noted during this literature review. There were a limited number of articles that were only geared towards the pediatric population. Most articles focused on adults when using key words that did not include pediatrics*, kids*, Teens*. Another limitation found was the number of articles that studied the effects fitness trackers had on weight but not how the devices increased physical activity in children.

Many of the articles chosen for the literature review had similar limitations. For instance, all of the studies in the articles were between 1 week and 4 months duration with no future follow ups. Another limitation, apart from timeframe, was sample size numbers. 11 articles out of the 14 were limited to a sample size below 300 participants with an average of 61 participants. Although there were clear and easily understood results for all studies most studies were limited to qualitative data and very little quantitative data with the exception of the accuracy and reliability articles. A few other limitations pertaining to specific articles in the literature review were: pedometers were easily lost, Pedometers were not used due to fear of breaking them because of high price point, the technology used in these studies are often no-longer state of the art, and lastly for a lot of the article this was the first-time pedometers were tested on the pediatric population.

DISCUSSION

The studies reviewed in this thesis provide the general population as well as health care providers with an overview of wearable fitness tracking devices and the pediatric population. Results from the articles reviewed revealed that wearable fitness tracking devices can be geared towards the pediatric population. While this literature review did not openly mention the physical or physiological effect wearable activity trackers have on the obese pediatric population, it did suggest that through gearing new wearable technology towards the pediatric population there is a potential for increased physical activity which can positively affect the obese pediatric population.

Design and Adherence

With the proper design, geared towards children and adolescents, the pediatric population may adhere to the use of wearable fitness tracking devices. The design that children and adolescents are more inclined to, includes devices they are able to customize, wear comfortably, used for any occasion, and are fun/engaging to use. For instance, in customizability children and adolescents would like the ability to Change casings (rubber, aluminum, gold, silver, silicone. All of different colors), change wrist bands (leather, silicone, mesh, gold, silver, nylon/fabric. All of different colors), change watch faces (digital, colors, analog, favorite characters). Next, fitting comfortable means children and adolescents have the ability to adjust bands to wrist size. Also, using the device for any occasion such as exercise (its main function), swimming, and formal events. Lastly, making these devices more engaging, perhaps involving games, an interactive screen, virtual awards, and the ability to stream music (wirelessly) (Schaefer et al., 2014). If these criteria for design are implemented in future devices, children and adolescents will bemore likely to adhere to the use of mobile and wearable fitness devices.

Accuracy and Reliability

During this literature review three of the articles concluded that wearable fitness tracking devices are a reliable source of information to use when tracking the physical activity of the pediatric population (Rowe et al., 2004; Rowlands, 2007; Wolff-Hughes et al., 2014). These devices can be used to determine the optimal number of minutes children should be receiving daily (Wolff-Hughes et al., 2014). While design and adherence have shown to encourage the pediatric population to wear these devices, the accuracy and reliability seen in these devices has suggested that they are good source of tracking how much physical activity children and adolescents are receiving daily, how much sleep the pediatric population is receiving, the range of heart rates seen in the pediatric population, and in some cases the number of calories these children and adolescents are in-taking and outputting daily. Children and adolescents are not the only ones how can benefit from the reliability of this information. Information received from these devices can be used in obesity management plans or obesity prevention strategies.

Behavioral Change Techniques

BCT's originate from the theory of self-efficacy (Mercer et al., 2016). Bandura's theory of self-efficacy describes the belief a person has in their ability to overcome obstacles or situations of adversity, or to complete a specific task. Once the individual's self-efficacy is applied to the obstacle or task, the experience can influence their sense of control over their own life outcomes. Increased self-efficacy can result when people put forth an increased amount of effort and keep a positive mindset that they can do it rather than giving in to self-doubt when faced with a difficult situation (Bandura, 1994). Included in this literature review were 3 articles that suggested there are multiple effective behavioral change technique to motivate obese children and adolescents

during intervention to reduce obesity, manage obesity, and prevent obesity (Edwards et al., 2014; Lindberg et al., 2016; Martin et al., 2013). Several BCT's evaluated in mobile and wearable fitness tracking devices are: providing feedback on consequences of behavior to the individual, environmental restructuring, Stress management/emotional control training, use of role model/position advocate, instruction on skills training, and initiating practice (Martin et al., 2013).

Barriers

There is one barrier not discussed in this literature review that pertain not just to design and adherence but also to accuracy and reliability as well as to behavioral change techniques. Finance, most wearable fitness tracking devices have shown to have a high price point. Also, if there is not a good or decent internet connection the results/tracking of these devices can be altered. With obesity being more prevalent in low-income populations this is a barrier that can affect the use of wearable technology in children (Horodynski et al., 2011).

RECOMMENDATIONS

Healthcare Providers

Wearable fitness trackers can be a step in the right direction when it comes to decreasing the prevalence of pediatric obesity. With the ability to share information between devices in this day-and-age health care providers can be more involved in the management or prevention of obesity seen in children and adolescents. With reliable data being gathered from these wearable fitness trackers healthcare providers can tailor interventions specific to any individual allowing for optimal results.

Parents

Parents play a major role in pediatric obesity. Children do not choose their diets their parents do. Parents are also at partial fault for increased number of screen time seen in children. However, parents can also be part of the solution with the ability to see a child or adolescents level of activity, number of hours sleep, and calories throughout the week better family decisions can be executed.

Education

One of the articles included in this literature review takes 61 third graders and ask them to play this exergame (exercise game) during physical education in school and measure their level of physical activity. Once these children were done they were interviewed, all eight students interviewed afterwards said they preferred playing the exergame over ordinary PE classes (Lindberg et al., 2016). Integration of wearable fitness tracking devices in schools could initiate more participation during physical education and increase the physical activity seen in the pediatric population.

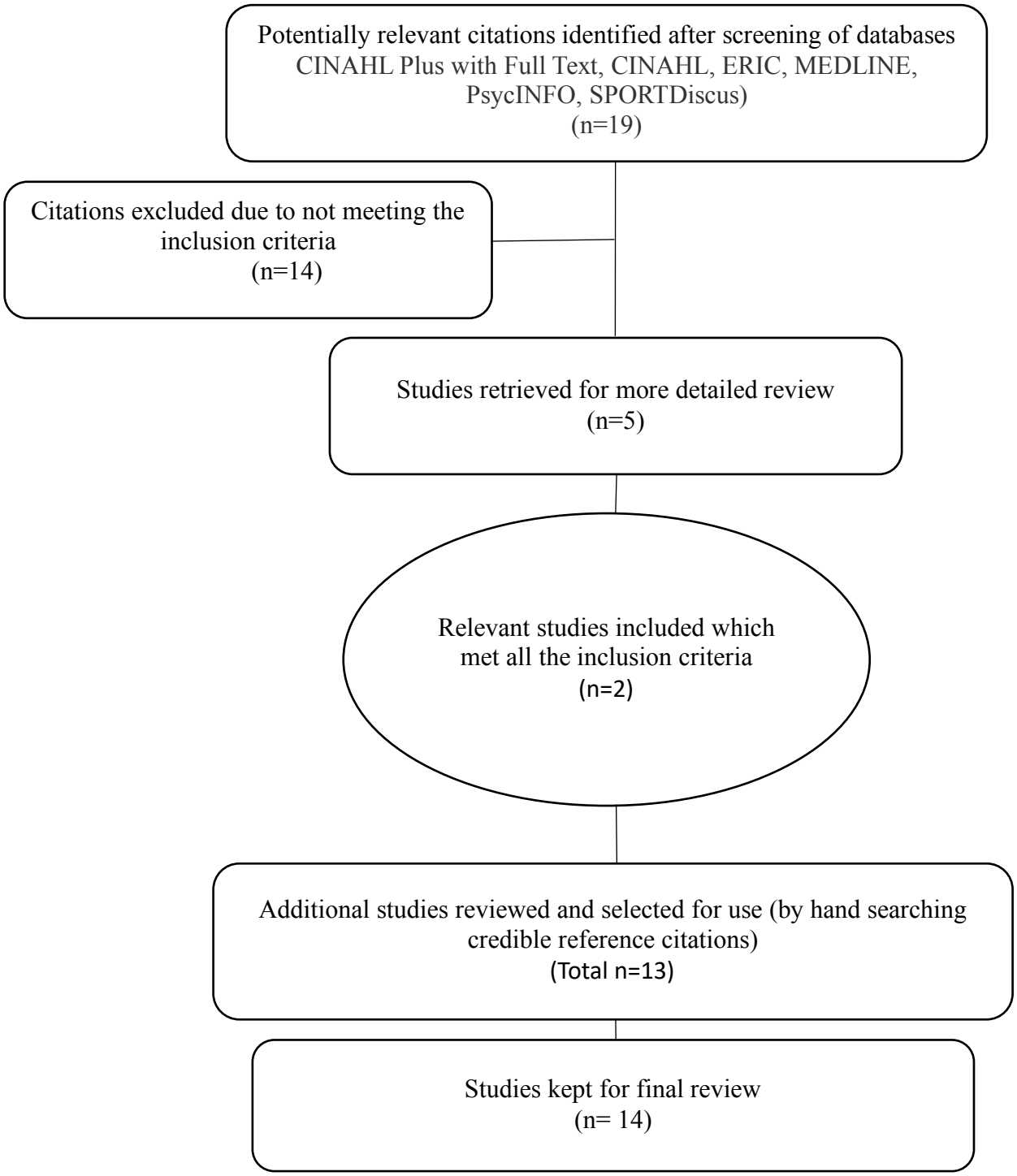
Research

Some recommendations for future research on wearable activity tracking devices can include a larger sample size. With a larger sample size results can be considered for the general population. Another important recommendation that may lead to a better understanding of the effects wearable fitness tracking devices have on the pediatric is to either included a follow up group after a year or two from the initiation of the study or a study that tracks the effects wearable fitness tracking devices have on the pediatric population over the period of a year or two.

CONCLUSION

The research suggests that wearable activity tracking devices if worn correctly, designed in a feasible manner for the pediatric population, and are more engaging through the use of exercise games and competitiveness such as the ability to share results, will produce the desired results of increased physical activity. Sharing data will also allow parent and medical professionals to encourage more activity and monitor activity for a more individualized intervention.

APPENDIX A:
CONSORT TABLE ARTICLE SELECTION PROCESS


Potentially relevant citations identified after screening of databases
CINAHL Plus with Full Text, CINAHL, ERIC, MEDLINE, PsycINFO, SPORTDiscus)
(n=19)
Citations excluded due to not meeting the inclusion criteria
(n=14)
Studies retrieved for more detailed review
(n=5)
Relevant studies included which met all the inclusion criteria
(n=2)
Additional studies reviewed and selected for use (by hand searching credible reference citations)
(Total n=13)
Studies kept for final review
(n= 14)

APPENDIX B: TABLE OF EVIDENCE

Author(s) Year Location	Study Design and Purpose	Sample Size	Intervention Protocol	Screening Measures	Results/Outcome	Key Findings and Limitations
Audrey et al. (2013) United Kingdom	exploratory randomized controlled trial Examine how adolescents Perceive accelerometer	n= 1000 8th grade students	Students were asked to wear their accelerometer for 7 days and follow up.	1000 8th grade students were asked to wear an accelerometer for 7 days	Results: If worn correctly accelerometers are an accurate form of measurement for physical activity.	Key findings: Students wanted something more comfortable and something they can wear with their best clothing
Carrion et al. (2015) Barcelona	3 group randomized trials Determine if wearable tracking devices are useful for teenager and if they can stay engaged for long periods.	n=30 G1= 10 (Boys) G2= 10 (Mixed) G3= 10 (Girls) 14-16-year-old	All received wearable life-style tracking devices to test for 1 week. Devices: D1- MisFit Shine D2 – Withings Pluse O2	Gathered 3 groups of ten 14-16-year-old teens from different high schools and asked to Report on a diary as well as register their impressions and perception of the device.	Results: Teens find that life-style tracking devices are useful for their age group. Knowledge: teens know very little about trackers. Impressions: initial instruction were difficult. Also, the devices are not geared towards teens. Important requirements: appealing, customizable, entertaining, and informative.	Key findings: Tracking devices are geared more towards older people and athletes. Wearable tracking devices allow to keep up with personal information and improve health/fitness. Having personal motivation was rated highly. Limitation: Teens believe the need for a tracking device is to have a health goal or a reason like sports to get one. Only used trackers for one week.
Clawson et al. (2010) United States	2-group randomized controlled trial	n= 50 School: S1 – 11	All participants were trained on how to use the game and system	trained participants to play the game and gave them the	Results: 49 – 50 of the teens were either somewhat	Key findings: Teens found the game engaging, but too easy. Sensor accuracy is not great.

	Evaluate a wearable health game and determine whether it will encourage physical activity	S2 – 39		chance to play two songs	satisfied or satisfied with playing the game Wearable tech: the comfort of the device was either agreed upon or strongly agreed upon. But not its performance. Workout: evenly split on whether it made the teens work hard or not.	Limitations: Data on the amount of calories burned, heart rate and other physiological measurements are not gathered.
Conroy et al. (2014) Netherlands	Controlled study The study was conducted to find different behavioral change techniques throughout the top mobile applications for physical activity.	n= 167 App stores: ITunes - 43 free - 49 paid Google play - 38 free - 37 paid	Top ranked health and fitness apps of 2013.	Each app had to be related to physical activity and descriptions were read and coded to determine the behavioral change techniques used	Results: The most common BCT used in mobile health and fitness apps was education and providing information of specific physical activity.	Key findings: Most apps use fewer than four BCT The information found in this study will a good source of information to develop future apps to prevent communicable diseases.
Edwards et al. (2013) United Kingdom	Field Study Find or think of a device that will motivate teenager to be physically active.	n= 18 GA = 6 GB = 6 GC = 6 Ages 11-14	Each group is given a different technology to use Handheld, Social Website, and Pedometers	18 adolescents ages 11-14 were recruited. Attitude towards exercise was recorded before and after the study. Daily logs of exercise and barriers met for six weeks	Results: The participants did not show a significant readiness to change their exercise behavior. However, rated themselves highly which means their exercise behavioral changes had already taken place.	Key findings: School work was rated the most likely reason to not exercise The lack of an exercise partner was the second most likely reason to not exercise Limitations: Time or the duration of the study Pedometers were easily lost Speed of Internet connection

Fairclough et al. (2015) United Kingdom	2 Arm randomized study Children compliance to wearing wrist worn accelerometer . Compare children's physical activity	n = 129 Boys n = 50 Girls n = 79	Participants were given a wrist worn accelerometer and a hip worn accelerometer	study measured anthropometrics, socioeconomic status, physical activity.	Results: 75% of the children participating were at a healthy weight. The girls were more somatically mature. Participants resided in some of the lowest SES neighborhoods in England. More kids prefer to wear the wrist accelerometer over the hip	Key findings: Wrist worn accelerometer promote better compliance in both children and adults Limitations: Device malfunctions (n=1) Software errors (n=5) Non-wear (n=8)
Lindberg et al. (2016) South Korea	Mixed method study Investigate the use of mobile and wearable exergames in physical education to increase physical activity in children.	n = 61 G1= 32 G2= 29 Third graders	The game uses sensors and heart rate meter to determine the physical activity of the player	61 third graders asked to play this exergame during physical education in school and measure their level of physical activity	Results: All eight students interviewed afterwards said they preferred playing the exergame over ordinary PE classes	Key Findings: The exergame increased the students heart rates the exergames motivate low skilled students to perform Limitation: Technical issues that were solved with restarting the game.
Martin et al. (2013)	Systematic Review Behavior change techniques, which one is the most effective in changing physical activity and	n = 17 (Articles) Obesity Management articles = 9 Obesity Prevention = 8	Articles that solely test the impact of physical activity, calorie control	17 articles were chosen from 135. Only Articles that solely test the impact of physical activity, calorie control.	Results: Obesity Management: 6 out of the 9 (67%) articles show effective behavioral changing techniques Obesity Prevention: Four Articles reported effective and four articles reported no change (50%).	Limitations: This was the first time that CALO-RE taxonomy was used on children. Lack of isolation to determine the effectiveness of the BCTs. There is little evidence supporting the use of BCT in childhood obesity programs.

	eating behaviors					
Rowe et al. (2004) United States	2 group controlled study Evaluate the reliability of pedometer data and reactivity of children wearing pedometers	n = 299 School A = 148 School B = 151	Report or record pedometer data for one week	299 middle school students ages 10-14 were recruited to record the data they receive from a pedometer they received from the researchers	Results: Reliability: the pedometers in this study were found to be a reliable source to determine activity in children. Reactivity: results showed that there was reactivity seen in children but no significant changes between day to say there was a hypothetical reactivity in children	Limitations: Feasibility with middle school children One week wear time
Rowland et al. (2007) United Kingdom	Literature review Review the status of accelerometer research specifically focused on children.	Unknown	Only use articles that involve children and accelerometers	A PubMed search with keywords like physical activity, children, and accelerometers	Results: Accelerometers are useful to determine a person's physical activity	Key findings: Accelerometers are being used to determine physical activity in kids more often. Seven days is the most reliable amount of days to measures someone's activity due to the daily variation
Schaefer et al. (2014) United States	Qualitative study To understand the feasibility of using wearable devices to measure	n = 25 7-10 years of age	Children were asked to measure their physical activity for 7 days	25 children of 7-10 years of age were given 3 different wearable tracking devices and measure their physical activity throughout 7 days	Results: The wrist worn Polar active was the most preferred devices Devices that's are comfy, fit well, have engaging aspects, and are water proof have	Key findings: Devices that's are comfy, fit well, have engaging aspects, and are water proof have higher feasibility and compliance levels

	physical activity in children			and complete a final interview.	higher feasibility and compliance levels	
Spruijt-Metz et al. (2015) United States	Systematic review Give an overview of the current technology that works with the obese population in three portions of their life; diet, physical activity, and sleep.	n = 5 (Articles)	Studies that use mHealth technology to aid the obese population	5 Studies were chosen that used mHealth technology to aid the obese population	Results: All in all technology has gotten and is getting more advanced such as; more feasibility, more personal and specific, more sophisticated physical activity tracking, and advancements in language and system processing allowing for less human to human trouble shooting.	Key findings: Tracker data had to be manually placed on to the apps now this is automated Limitations: More behavioral models have to be made
Turner et al. (2014) United States	Systematic review Reviews the current use of mobile and wearable devices to prevent or treat pediatric obesity	n = 41 (Articles)	Articles were chosen based on feasibility, usability, pediatric obesity, mobile technology.	Articles with pediatric population ages 0-19, used mHealth, obesity prevention or treatment, self-monitoring,	Results: mobile and wireless devices are a feasible and acceptable way to prevent and treat pediatric obesity.	Key findings: Wearable tracking devices are feasible Limitations: Trials are not stand-alone Trials are not long-periods Technology used is often no longer "state-of-the-art".
Wolff-Hughes et al. (2014) United States	Randomized controlled trials Determine age and gender specific percentiles for	n = 3698	Youth ages of 6 years old to 19 years old with at least 4 day and more than 10 hours of wear time	Subjects wore the actigraph model 7164 for 7 days while awake and removed it while showering and swimming	Results: Males, the median activity level was 441,431 TAC/d, with approximately 53 min/d of MVPA and 368 min/d of LPA.Females, the	Key findings: These results give a good estimate as to the total amount of physical activity children and adolescents should be getting.

	TAC (total activity count) per day, mintues for MVPA (moderate to vigorous physical activity), and minutes of LPA (light physical activity).				median activity level was 234,322 TAC/d, with approximately 32 min/d spent in MVPA and 355 min/d of LPA	

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