Informing the Creation of an Evidence-Based App for Daily Physical Activity in Schools

by

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The above committee determined that the thesis is acceptable in form and content and that a satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate during an oral examination. A signed copy of the Certificate of Approval is available from the School of Graduate and Postdoctoral Studies.

ABSTRACT

It has been well document that physical activity has positive effects on physical health and well-being, as well as academic performance. In contrast, sedentary behaviour has been associated with negative health implications, such as increased prevalence of diabetes and obesity. As children are leading a physical inactive lifestyle, an intervention is required. Daily physical activity (DPA) is a mandated 20 minute policy that was implemented in school systems with the goal of increasing activity levels of students in the classroom. However, implementing DPA is challenging for a number of reasons. Technology, specifically a mobile application, is a potential resource that could increase the feasibility DPA and physical activity levels in children. Therefore, the purpose of this thesis was to complete an environmental scan of the app market to identify strengths and weaknesses of existing apps relevant to DPA. Through an environmental scan and focus group interviews it was determined that apps that were gamified and included a greater number of behaviour change techniques exhibited a higher perceived quality than those excluding gamification techniques. Further, it was identified that teachers face various constraints in the classroom and have inadequate resources to properly implement DPA in the classroom. These findings can inform the creation of a physical activity based app for the classroom.

Keywords: children; youth; education; mhealth; app store

AUTHOR'S DECLARATION

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The research work in this thesis was performed in compliance with the regulations of UOIT's Research Ethics Board/Animal Care Committee under **REB Certificate #14426**.

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STATEMENT OF CONTRIBUTIONS

I hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication. I have used standard referencing practices to acknowledge ideas, research techniques, or other materials that belong to others. Furthermore, I hereby certify that I am the sole source of the creative works and/or inventive knowledge described in this thesis.

All of the work is this thesis was written by myself, with edits provided from Dr. Shilpa Dogra and Dr. Nick Wattie. All data was collected by myself, and I was also the primary investigator on the environmental scan. During the app search in the environmental scan, a 2nd and 3rd reviewer were utilized. These individuals are research assistant Mitchell Wolf and fellow Master's student Jacqueline Brown.

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LIST OF ABBREVIATIONS AND SYMBOLS

Apple	App Store
App(s)	Mobile Application(s)
AVGs	Active Video Games
BCTs	Behaviour Change Techniques
BMI	Body Mass Index
CI	Confidence Interval
COREQ	Consolidated Criteria for Reporting Qualitative Research
CSEP	Canadian Society of Exercise Physiology
DCDSB	Durham Catholic District School Board
DPA	Daily Physical Activity
EQAO	Education Quality and Accountability Office
HDL	High-Density Lipoprotein
ID	Interpretive Description
kg	Kilogram
MARS	Mobile App Rating Scale
METS	Metabolic Equivalents
mHealth	Mobile Health
MVPA	Moderate-to-Vigorous Physical Activity
OPHEA	Ontario Physical Health and Education Association
PD	Professional Development
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QOL	Quality of Life
RCT	Randomized Control Trial
TV	Television

Chapter 1. Introduction

1.1 Current Physical Activity Levels in Children

Physical activity can be defined as a variety of body movements that engage skeletal muscles and therefore results in energy expenditure (Caspersen, Powell, & Christenson, 1985). Physical activity is not only important, but crucial for overall health and well-being (Maher et al., 2013). Individuals who lead physically active lives tend to not only live longer and have a decreased rate of morbidity, but also report higher levels of quality of life (QOL) (Maher et al., 2013). In order to maintain physical activity levels throughout the lifespan, this lifestyle needs to be established at a young age, as leading a physically active lifestyle as a child can increase the likelihood of doing so throughout adulthood (Warburton, Nicol, & Bredin, 2006). If children do not learn the importance of physical activity, and how to lead a physically active lifestyle by developing the proper motor skills and self-efficacy, there is a minimal chance they will do so as an adult (Warburton et al., 2006). For these reasons, it is beneficial to highlight the importance of a physically active lifestyle from a young age in hopes of preventing negative health outcomes throughout the lifespan and allowing for a healthier life both physically and mentally.

Currently, many children across Canada live a sedentary lifestyle, in which they spend a significant amount of their time in ways that does not increase energy expenditure above the resting level (Pate, O'Neill, & Lobelo, 2008). For example, research suggests they are spending 62% of their waking hours (n=8.6) in a sedentary state (Colley et al., 2011). Sedentary behaviour is associated with an increased risk of developing cardiometabolic diseases, such as diabetes, obesity, cardiovascular disease, and high blood pressure, all of which can lead to premature death (Tremblay, Colley, Saunders, Healy, & Owen, 2010). Sedentary behaviours and sedentary screen time during discretionary time (e.g., watching television (TV), playing video games, and using a computer: Tremblay et al., 2011) can have negative effects on children's performance in school, sleep patterns, mental health, and interaction with family (Hale & Guan, 2015; Faught et al., 2017). This can influence children's overall quality of life, can impact their future job careers due to poor academic performance, and have a negative effect on family relationships (Sigman, 2012). For this reason, it has been recommended that screen time and sedentary behaviour in children and adolescents of ages five to 17 should not exceed more than two hours a day, as most time should be spent being physically active (Tremblay et al., 2011).

Guidelines disseminated by the Canadian Society of Exercise Physiology (CSEP) in Canada state that children and adolescents of the ages five to 17 years should aim to accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA: a mixture between moderate level activity; activities equivalent in intensity to brisk walking, and vigorous level activity; activities that produce large increases in breathing and heart rate such as jogging: MVPA, 2009) every day, including aerobic activities (Tremblay et al., 2016). As well, vigorous activities, and muscle and bone strengthening activities should each be incorporated at least three days a week (Tremblay et al., 2016). Research indicates that children are not reaching these outlined guidelines and instead, are too sedentary (Colley et al., 2011).

Daily Physical Activity (DPA)

Daily physical activity or DPA is a provincially mandated school activity that requires teachers to engage their classroom in 20 minutes of MVPA daily (Stone, Faulkner, Zeglen-Hunt, & Bonne, 2012). DPA was implemented with the intention of increasing the current physical activity levels (Stone et al., 2012) and is not restricted or limited to a specific activity or curriculum for teachers. Due to a current lack of resources and various other barriers surrounding DPA, such as lack of time and space, teachers are not including DPA into their schedules to the degree they should (Strampel et al., 2014). A resource that could assist teachers in properly implementing DPA into their classroom is required.

There is an opportunity for a novel intervention in the field of mHealth (i.e., the use of a mobile applications for health purposes: Akter & Ray, 2010). Therefore, our research will focus on gaining knowledge of the app market, as well as the perspectives of teachers to inform content and direction of a mobile app that can be used as a resource and tool for teachers to use during DPA in the classroom.

1.2 Feasibility of Using A Mobile Application in the Classroom for DPA

Currently, there are very few apps that are designed specifically for DPA in the classroom, unlike subjects such as math which have a rich selection (n=4000) of mobile apps for support (Larkin, 2013). The apps specifically designed for DPA that exist use pedometers or exercise videos to facilitate an increase in physical activity levels and accumulation (Kermarrec, Guillodo, Mutambavi, & Ballarin, 2015).

In order to fully understand the feasibility of a mobile app in the classroom and why teachers are not engaging in DPA sessions at the rate they should, one must also identify and understand the constraints they may be facing. Constraints can be considered as something that can limit or assist in shaping the development of a movement, or in this case, can be used to examine the feasibility of an app and the reasoning behind the lack of DPA involvement (Renshaw, Chow, Davids, & Hammond, 2010).

Once constraints have been identified, one can begin to develop an app that will address the lack of DPA while also addressing the constraints teachers face regarding DPA implementation.

1.3 EduApps

This thesis was part of a bigger project named EduApps, which is a research program funded by an Ontario Research Fund: Research Excellent grant that involved multiple institutions. EduApps had the goal of creating evidence-informed apps for teachers to use in the classroom for resources, with some being congruent with the curriculum. EduApps contained three thematic zones, which were Mind, Body, and Community. The work in this thesis was conducted within the Body Zone working group. In my thesis, we wanted to ensure we were not creating an app similar to what is currently available. For that reason, we examined the app market to identify what apps are currently available for DPA to identify current gaps within the market that needed to be addressed. The information found within this thesis could then be used to inform the creation of a physical activity based app, ensuring it was evidence informed, to be used within the classroom as a resource for teachers to use during DPA.

1.4 Purpose and Rationale of Study

Physical inactivity in children has become a major public health concern, and evidence-informed interventions are required. Since technology is a growing field with many possibilities, the feasibility of creating a mobile app that is used as a resource to increase DPA should be explored. In order to create an evidence based physical activity app, we must first identify the current apps available for children to use during DPA, and the constraints that inhibit proper DPA implementation.

1.5 Research Questions

The overarching goal of this thesis is to inform the creation of an original mobile app that can successfully be implemented in Ontario schools' DPA policy to increase physical activity levels and decrease prolonged sedentary behaviour. This goal will be met using two studies, employing different methodologies.

Study 1 – Environmental Scan

What types of physical activity mobile apps are available for teachers to use in the classroom during DPA? What are the effective behaviour change and gamification techniques used in these apps to increase physical activity levels and engagement?

Study 2- Focus Group Interviews

What resources and constraints do teachers perceive with respect to conducting DPA in the classroom? Is there interest in an mHealth solution?

1.6 Specific Hypotheses to Research Questions

Study 1 – Environmental Scan

We hypothesize there will be little to no apps specific for teachers that could be used for DPA in the classroom. We hypothesize there will be physical activity apps for children, but that they will be online arcade style games, rather than apps designed as behaviour interventions to increase activity, as seen in the literature (Fitzgerald & McClelland, 2017). We anticipate the apps that are designed to increase activity will include goal-setting and step tracking (Renshaw et al., 2010). We expect many apps will not be age appropriate and will be of a 12+ or 17+ age rating, which will not be significant to our age group of nine to eleven (Fitzgerald & McClelland, 2017).

Study 2 – Focus Group Interviews

We hypothesize teachers will feel unqualified, unprepared, and uncomfortable with conducting DPA sessions as seen in the literature (Strampel et al., 2014). We expect that a lack of time, space, and resources will be additional constraints, which was also seen in the literature (Strampel et al., 2014). It is also likely teachers will feel as though they are not properly trained to conduct DPA sessions, as this was a common theme found in previous interviews with teachers (Stone et al., 2012). Further, we expect that teachers will have a positive approach to the interest in an mHealth solution. As the literature has highlighted that teachers often discussed a lack of resources, we expect that teachers will react positively to this proposition (Strampel et al., 2014).

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Chapter 2. Literature Review

2.1 Purpose Statement

The purpose of this chapter is to review the literature on the utility of mobile applications for improving movement behaviours among school aged children in the classroom in Canada. Specific considerations will be given to following aspects: defining physical activity and physical activity guidelines; the importance/benefits of physical activity; defining sedentary behaviour; the negative health impact of sedentary behaviour and screen time; the current level of physical activity and sedentary time; the daily physical activity (DPA) protocol and its benefits to health; current resources available to teachers for DPA and current level of success for DPA implementation; current physical activity based mobile applications available to the public; the effectiveness of mobile apps for increasing physical activity and reducing sedentary time; behaviour change techniques integrated within mobile applications to increase movement behaviours; challenges associated with integrating DPA into classrooms and the school system; and any other important considerations.

Defining Physical Activity and Sedentary Behaviour

Physical activity (a variety of body movements that engage skeletal muscles and therefore results in energy expenditure: Caspersen, Powell, & Christenson, 1985) can come in a variety of forms, from walking and running, to cycling, swimming, dancing, and various sports. As physical activity has such a wide range of forms, it can be appealing to all individuals with different interests and can also be a social event. Along with this, different types of physical activity have different benefits and levels of difficulty. In terms of cardiorespiratory effect, physical activity is most often grouped into three categories: light, moderate, and vigorous, although there can be crossover between these categories (Tremblay et al., 2011a). Physical activity can also include resistance and strength training (Tremblay et al., 2011a) and can be either anaerobic or aerobic. Aerobic activity consists of any sort of cardiovascular activity that gets one's heart beating and increasing breathing rate, for example, running and swimming, that requires oxygenated blood to be distributed to working muscles (Bloomer & Goldfarb, 2004). In contrast, anaerobic exercise does not require oxygen to muscles and consists of exercise such as weight training and sprints where one is easily out of breath in a short period of time (Bloomer & Goldfarb, 2004).

Sedentary behaviour is defined as any form of walking behaviour that is categorized as an energy expenditure of less than, or equal to 1.5 METS, and also includes sitting or reclining (SBRN, 2017). Screen time is a form of sedentary behaviour that involves one's posture being in a seated or prone position, while using a screen, whether it be watching TV, using social media on a device, or playing video games (Tremblay et al., 2011b).

Physical Activity & Sedentary Behaviour Guidelines

Movement guidelines created by the Canadian Society for Exercise Physiology (CSEP) are available for different age groups, zero to four years, five to 11 years, 12 to 17 years, 18 to 64 years, and 65+ years (Tremblay et al., 2011a). These guidelines indicate the amount of activity individuals should be aiming to achieve, as well as the duration, level of activity such as moderate- to vigorous-intensity (MVPA, a mixture between moderate level activity; activities equivalent in intensity to brisk walking, and vigorous level activity; activities that produce large increases in breathing and heart rate such as jogging: MVPA, 2009), strength training, and types of activities that can be done to achieve these weekly guidelines.

Guidelines disseminated by CSEP in Canada state that children and adolescents of the ages five to 17 years should aim to accumulate at least 60 minutes of MVPA every day, including aerobic activities (Tremblay et al., 2016). As well, vigorous activities, and muscle and bone strengthening activities should each be incorporated at least three days a week (Tremblay et al., 2016).

2.2 Importance/Benefits of Physical Activity in Children

It is well documented that physical activity is beneficial to overall health and well-being (Maher et al., 2013). Physical activity benefits are wide ranging, from lowering cholesterol and blood pressure to improving mental health and social skills (Maher et al., 2013). Physical activity is also beneficial to all age groups, whether it be middle aged individuals, the older adult population, and children. In terms of children, establishing a physically active lifestyle in younger years is not only beneficial, but can be crucial in terms of adherence to an active lifestyle as an adult (Currie et al., 2009).

The benefits of physical activity at the levels described by current guidelines are numerous and range in effect and severity. As a whole, for all age groups, physical activity has been shown to decrease the risk of developing cardiovascular disease, type 2 diabetes, cancer, specifically breast and colon cancer, and osteoporosis in the elderly years (Warburton et al., 2006). More specifically to children, physical activity has been shown by many research studies to have positive effects on decreasing the risk of developing obesity, on improving musculoskeletal health and fitness, and different components of cardiovascular health (Janssen & LeBlanc, 2010). Physical activity also has psychological benefits on children and is beneficial for mental health, as well as success in school (Hale & Guan, 2015; Faught et al., 2017). As obesity is becoming an epidemic, it is beneficial to highlight the importance of leading a physically active lifestyle throughout childhood and into adulthood. In another research study it has been shown that physical activity can also have positive effects on blood pressure in normotensive children, lipoprotein and plasma levels, academic success, and mental health, such as depression and anxiety (Strong et al., 2005).

To emphasize the importance of these benefits, a systematic review of the literature by Janssen and LeBlanc (2010) examined randomized control trials (RCTs) and cross-sectional studies to understand the effect of physical activity on cholesterol and blood lipids, high blood pressure, metabolic syndrome, obesity, bone mineral density, and depression in children. The review suggested that MVPA produced a significant improvement in at least one lipoprotein in children who presented with high cholesterol, high blood pressure, and obesity, but only when the studies were based on aerobic exercise alone (Janssen & LeBlanc, 2010). There was an effect size (using a 95% confidence interval) of -3.03 for triglycerides and 0.26 for HDL cholesterol (Janssen & LeBlanc, 2010). In one of the examined studies, using a RCT design, the intervention included 60 to 180 minutes/week of prescribed exercise for 4 to 25 weeks, where there were significant reductions in systolic blood pressure in response to aerobic training (Janssen & LeBlanc, 2010). In terms of metabolic syndrome, using aerobic exercise it was also found that there were significant improvements in at least one of the insulin variables (Janssen & LeBlanc, 2010).

In addition, when examining obesity in this review, it was found that in 17 intervention studies with a RCT design, that there were significant changes in body mass index (BMI), total fat, and abdominal measures in response to training (Janssen & LeBlanc, 2010). The interventions used in these studies ranged from four weeks to two years in duration, on average being four to six months in duration. The exercise that was prescribed was to be completed at home for typically two to three and a half hours per week and consisted of aerobic exercise. Activity was either tracked by accelerometer and pedometers, or participants were to record data through self-reported questionnaires. The effect size was -0.40 for percent body fat and -0.07 for BMI (Janssen & LeBlanc, 2010). In terms of bone mineral density, eleven studies were examined that used a physical activity exercise program consisting of moderate-to-high strain anaerobic activities, such as resistance training exercises of jumping and high impact weight bearing (Janssen & LeBlanc, 2010). It was found that as little as 10 minutes of moderate-to-high impact activity two or three times a week could have a modest effect on bone mineral density when combined with aerobic weight bearing activities (Janssen & LeBlanc, 2010). When examining six studies on depression, it was found that with 60 to 90 minutes of aerobic exercise per week for a duration of eight to 12 weeks, there was a significant improvement in at least one depressive symptom (Janssen & LeBlanc, 2010).

2.3 Negative Health Impact of Sedentary Behaviour and Screen Time in Children

In opposition to physical activity, it has been established that sedentary behaviour can lead to adverse health outcomes and a lower quality of life (QOL). Screen time is considered to be a large factor contributing to sedentary behaviour (Salmon, Tremblay, Marshall, & Hume, 2011). In the last few decades, the exposure to TV has begun much earlier in life. In the year 1971, children began watching TV at the average age of four, but are now beginning to watch TV at the average age of five months, which is thought to be due to the increasingly affordable price of electronics and ease of access and entertainment (Salmon et al., 2011). This promotes screen time at a younger age and exposes children to a more sedentary lifestyle (Salmon et al., 2011). It has been seen in many studies that sedentary behaviour and large amounts of screen time can result in increased risk of developing obesity or becoming overweight (Salmon et al., 2011; Sardinha et al., 2008). The correlation between sedentary behavior and obesity comes from a lack of energy expended and an increase in “unhealthy” foods that typically are associated with watching TV, such as sweet and salty treats with high fat and sugar (Salmon et al., 2011).

Furthermore, a cross-sectional study in Portugal examining 5000 12 year old males found that per every hour spent being sedentary a day, children were 32% more likely to be obese, a potentially considerable number (Sardinha et al., 2008). It was also found that with physical activity and less sedentary time, these results could be reversed (Sardinha et al., 2008). It is evident that physical activity has positive effects on health, while sedentary behaviour can have detrimental effects on health that can later effect adulthood and be carried throughout life.

In addition to the first study’s finding, it was also discovered that sedentary behaviour (i.e., social media, TV, video games) can be associated with increases in tobacco use, drug, and alcohol abuse (Salmon et al., 2011). The study also identified that screen time and sedentary behaviour can have negative effects of socio-cognitive outcomes. Increased screen time can expose children to violence at a younger age, potentially bringing out violent tendencies including aggression and antisocial behaviour in children aged zero to 18 years (Salmon et al., 2011). Increased screen time can also lead to poor attachment and bonding between parents and children who are "heavy users" of screen time (Salmon et al., 2011). This results in increases in children getting in trouble in and outside of school, oftentimes experiencing more frequent feelings of sadness and boredom (Salmon et al., 2011).

Furthermore, excessive bouts of sedentary behaviour and screen time that exceed recommendations of two-hours a day has further serious effects on the health of children. A study in Europe examined the effects of excessive sedentary behaviour in children. The study observed the effects sedentary behaviour has on metabolism and body fat, cardiovascular disease, mortality, sleep disturbances, mental health, educational achievements, and family interaction. In terms of metabolism and body fat, it has been suggested that increased sedentary behaviour and screen time can be a larger contributing factor to obesity in children than poor diet (Sigman, 2012). The study also identified that there is a correlation between screen time and body weight. For every hour spent watching TV there is an associated extra one kilogram of body fat, which is caused by the decreased rate of metabolism and calories burned, as well as increased food intake that often accompanies TV watching (Sigman, 2012). When focusing on cardiovascular disease, the article identified that sedentary behaviour may be associated with an increase in children's blood pressure, also known as hypertension (Sigman, 2012). Children who watched two to four hours of TV daily were 2.5 times more likely to have high blood pressure (hypertension), as compared to children who watch less than two hours a day (Sigman, 2012).

Links have also been made between sedentary screen time and mortality. A study by the American Heart Association discovered, when following individual (n=8,800) of the ages 25 and older for 6.5 years, that every hour spent sedentary watching TV was associated with an 18% increase in death cause by heart disease, and an 11% increase in mortality by various causes (Sigman, 2012). When daily sedentary TV watching became four or more hours, these numbers increased to 80% more likely to die of cardiovascular disease, and 46% more likely to die of various causes, than those who are sedentary for less than two hours a day (Sigman, 2012). Sedentary behaviour can also have an effect on sleep patterns, which can be concerning as sleep is important for children in terms of development. It has become well documented that children are getting less sleep than previous generations due to increases in TV exposure at a young age (Sigman, 2012). A study examining children (n=2068) found that increased sedentary screen time was a large contributing factor on sleep disturbances (Sigman, 2012). Likewise, sedentary behaviour and increased screen time also effects mental health, educational achievements, and family interaction. A 26-year longitudinal study found that increased screen time through television from birth to adulthood resulted in poorer academic performance, specifically to socio-economic status, reduced overall well-being, and decreases in classroom engagement and math achievement, than those who watch less TV (Sigman, 2012). When mixed with a lack of physical activity, increased sedentary behaviour and screen time, specifically social media, was identified to increase depressive and lonely feelings (Sigman, 2012). Lastly, an increase in screen time was found to negatively impact family relationships. It was discovered through a study by

Stanford University that one hour of screen time reduces family interaction by up to 24 minutes (Sigman, 2012).

Lastly, it has been found in many studies that increased sedentary and screen time can result in poor cognitive development, effect short term memory, hinder academic success and language skill development, and decrease attention span and vocabulary skills in children (Salmon et al., 2011). It is evident from all of these research findings that leading a sedentary lifestyle as a child can have many detrimental effects not only on health, but also academic performance. Leading a sedentary life as a child can progress to obesity throughout life and can potentially hinder one's success in school, affecting job potential. It is evident that a physical activity intervention needs to be established to decrease prolonged sedentary periods.

2.4 Current Level of Physical Activity and Sedentary Time Among Children in Canada

In order to understand the level of physical activity of children in the classroom, we must identify the current level of physical activity among children across Canada in general. If children are sedentary for hours in the classroom and are also sedentary after school hours and on weekends, it is difficult for them to meet the recommended guidelines. One should aim to establish a baseline of how active the child population is. Once a baseline is established, researchers can develop exercise programs that increase the children's level of activity in a positive manner, while also decreasing prolonged periods of sedentary time. Multiple programs would have to be produced to combat the different barriers behind a lack of physical activity, as well as fit different types of individuals (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004). In order to identify the utility of a mobile app on movement behaviours, we must have an idea of how active children are and the barriers that decrease their involvement in activity.

In articles by two groups of authors, the number of children meeting the physical activity guidelines, as well as their levels and patterns of physical activity were examined. The first study by Riddoch et al., (2004) examined the feasibility of using accelerometers to measure children's activity levels in Europe. They found that males in the age range of nine to 15 years tend to be more physically active than females, being 21% more active at age 9 (66 vs. 54 mins/day, $p<0.05$), and 26% more active at age 15 (45 vs. 32 mins/day, $p<0.05$)" (Riddoch et al., 2004, p. 90). They also concluded that activity levels decline as children age, most likely due to the increased dropout rate of sports (Riddoch et al., 2004), due to changes such in body appearance, and/or changes in motivation.

An article by Pate et al., (2002) also used accelerometers to track activity levels in children from the United States. They found that almost all children (90%) in their study (grades one to 12) met the guidelines for moderate activity, while very few (3%) made the guidelines in terms of vigorous activity (Pate et al., 2002). Similarly, a study by Bornstein, Beets, Byun, & McIver (2011) found when examining 6309 preschoolers that only 5.5% were achieving MVPA every day per week (Bornstein, Beets, Byun, & McIver, 2011).This is concerning as children should be engaging in a much higher level of component of decreasing chronic diseases (Janssen & LeBlanc, 2010). Another study found that children between the ages of two and 18 spend two to four hours a day engaging in screen time and five to 10 hours a day being sedentary, a concerning total of up to 14 hours a day out of 24 hours engaging in only 1.5 METS expenditure, increasing detrimental effects on their health (Colley et al., 2011; Salmon et al., 2011). Furthermore, research has identified that children spend ~40% of their 24 hours a day sleeping, and ~40% of their 24 hours a day engaging in sedentary behaviour (Ridgers, Stratton, & Fairclough, 2006). Excluding the time spent sleeping (as sleep is an important and essential activity required for optimal health and academic performance), this is a concerning statistic as almost half of children's days are spent being sedentary (Ridgers et al., 2006). Based on these statistics it is clear that children lead too sedentary of a lifestyle (Salmon et al., 2011; Sardinha et al., 2008; Ridgers et al., 2006). As development is constant throughout childhood and obesity prevalence has been increasing over the last few decades, it is important to aim to decrease the amount of time children spend sedentary and emphasize the importance of physical activity, increasing the chance of children living an overall healthy lifestyle (Guallar-Custillón et al., 2014).

Screen time (i.e., watching TV, spending time on a mobile device) is a significant contributor to sedentary behaviour. Self-reports have shown that children spend six hours a day on weekdays, and seven hours a day on weekends engaging in screen time (Tremblay et al., 2011a; Colley et al., 2011). This includes activities such as sitting in classrooms, watching TV, talking on the phone, and using a computer (Colley et al., 2011). Research using accelerometers to measure activity in youth aged nine to 16 for seven days has demonstrated that on average, the youth were sedentary for 8.6 hours (507 minutes for boys; 524 minutes for girls) per day (Colley et al., 2011, p. 4). This sedentary time accounted for approximately 62% of their waking hours (Colley et al., 2011, p. 4). Additionally, youth in this study spent only four hours a day in light intensity physical activity, such as walking and activities of daily living, and just over one hour a day (61 minutes) in MVPA for boys, and 47 minutes a day for girls (Colley et al., 2011). MVPA includes activities such as riding a bike and playing on outdoor equipment (Tremblay et al., 2011b). This consisted of 97% of youth participants being within only moderate level activity and as few as 3-4% of youth participants completing 20 minutes a day of vigorous activity, three days a week (Colley et al., 2011). Of the youth participants (n=1608), only 7% accumulated at least 60 minutes of MVPA at least six days a week (Colley et al., 2011). These findings are concerning as it is clear children spend most of their waking hours being sedentary, rather than engaging in activity that would be above resting level.

Based on these findings, it is clear that currently children are not meeting physically activity guidelines. As such, practitioners, researcher and parents need to consider multiple opportunities to promote physical activity opportunities and reduce sedentary behaviour. It has been suggested in previous studies that school can be an opportunity to engage in physical activity and reach daily physical activity guidelines, particularly given the significant proportion of time youth spend at school.

2.5 Current Physical Activity Interventions

The intervention strategies that are currently used to increase physical activity among children are: after school interventions, school-based interventions, pedometer-based interventions, family-based interventions, and internet/app-delivered interventions.

For ***after-school and school-based interventions***, children engaged in programs such as soccer, dance, general physical activity, and aerobic fitness following school hours in order to increase over physical activity levels (Pate & O'Neill, 2009). Unfortunately, the results of these programs were mixed, with only around half producing positive increases in physical activity levels (Pate & O'Neill, 2009). The main reason behind these programs not being successful is finances and lack of transportation in low income families (Pate & O'Neill, 2009). Another barrier can be access to equipment (Dobbins, Husson, DeCorby, & LaRocca, 2013). Research on this type of intervention is also limited. In terms of ***pedometer-based interventions***, students wore pedometers during the school day to track how many steps they complete per day, with the intent of increasing physical activity levels through the utilization of behaviour change techniques. Researchers found overall positive increases in physical activity level amongst both males and females, but the pedometers themselves presented issues, decreasing the success of this type of intervention (Horne, Hardman, Lowe, & Rowlands, 2009). Some examples of the issues with the pedometers were that data was not collected on weekends as this type of intervention occurred at school, the information self-reported in devices that utilize pedometers can be incorrect due to personal error, and the pedometers cannot measure activity levels during swimming or cycling (Horne et al., 2009). Therefore, this type of intervention is not always reliable.

Further, for the ***family-based interventions***, it aims at including family members by recording physical activity levels of the children within the family. These interventions are shown to have a positive effect on physical activity, but little research has been conducted on this type of intervention, and therefore, the success behind this intervention is not currently identified or understood (Brown et al., 2016). In terms of the last type of intervention, ***internet/app-delivered interventions***, they utilize internet sources, as well as mobile applications to increase physical activity levels. These intervention strategies were found to increase physical activity levels in a small, but significant amount that would produce powerful behaviour changes at a population level (Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012). As this type of intervention has only become fairly recently researched, it is an area that has positive promise and should further be researched to have a better understand of its benefits and possibilities.

2.6 Daily Physical Activity (DPA) Protocol and Its Benefits

If children engage in active play during recess and/or in the classroom, and engage in physical education class, it could contribute to between five and 40% of the recommended physical activity guidelines without any activity outside of school hours (Chaput et al., 2014). Unfortunately, it appears as though children are not using recess and playground equipment to engage active play (Chaput et al., 2014). Likewise, active play within classrooms and physical education curriculum are not being incorporated into children's schedules effectively, preventing children from reaching physical activity guidelines (Chaput et al., 2014). As a result, in 2005 daily physical activity (DPA) became a mandatory provincial policy within the province of Ontario.

DPA became mandatory for children in grades one through eight (Stone, Faulkner, Zeglen-Hunt, & Bonne, 2012). The official description of DPA states that it is to be 20 minutes in duration and is to be at the MVPA level in terms of intensity (Stone et al., 2012). DPA was implemented with the goal of increasing the current physical activity levels to aid children in meeting recommended daily levels of physical activity (Stone et al., 2012). DPA was not restricted to the classroom and could occur in the gymnasium or outdoors (Stone et al., 2012). It was also not restricted to a particular activity, allowing teachers the freedom to do as they please, as long as they were implementing it into their daily schedules and children were receiving a full 20 minutes of MVPA level activity (Stone et al., 2012). Importantly, the notion of DPA emphasizes increasing physical activity engagement and reducing the prolonged sedentary periods that occur in class throughout the day. DPA is a mandatory policy that is open-ended and does not follow a strict curriculum, it could provide a solution to assist children in achieving movement behaviour guidelines and health benefits that will lead to a better QOL (Guallar-Castillón et al., 2014).

Benefits to Health

Similar to physical activity, as DPA is a form of exercise, thus, it has many positive outcomes on one's health. As DPA should consist of activities that are at the MVPA level, the aim of DPA should be to get children's heart rate increasing, producing an aerobic effect (Allison et al., 2014). The increase in heart rate, along with the reduction of prolonged sedentary periods decreases the likelihood of developing obesity, type 2 diabetes, chronic diseases, and cardiovascular disease, both in childhood and later in life (Allison et al., 2014). As seen in the study by Stone et al., (2012), it was found though that students who participated in DPA every day had higher levels of physical activity, achieved a greater overall intensity level of physical activity, and accumulated significantly more minutes of MVPA across the school week, showing the positive effects DPA has on physical activity behaviour if properly implemented (Stone et al., 2012).

2.7 Current Level of Success for DPA Implementation in the Classroom and Current Resources Available to Teachers

Current Level of Success for DPA Implementation

Unfortunately, it has become evident that teachers are not incorporating DPA into their schedules to the degree or intensity they should be. Based on a study of students (boys n= 478 and girls n=549) in the Toronto District School Board (schools n=16), only 49% of students participated in DPA every day of the school week, with 16.6% participating in DPA two days per week, 17.9% participating in DPA three days per week, and 16.1% participating in DPA four days per week (Stone et al., 2012). Therefore, children lack the 20 minute period of active play that could increase physical activity levels and reduce prolonged sedentary times, potentially decreasing their chance of achieving the health benefits associated with activity (Stone et al., 2012). The main reason behind a lack of DPA implementation, include barriers such as lack of resources, space, and time (Robertson-Wilson & Lévesque, 2009). It is thought that if organizations supported the implementation of DPA, such as the Ontario Physical and Health Education Association (OPHEA), there could be an increase in DPA engagement (Robertson-Wilson & Lévesque, 2009).

Currently, DPA is not being implemented as intended due to the main barriers of time, space, and a lack of resources. Teacher often stated they felt as though they were provided with minimal resources to conduct DPA, often causing them to neglect implementing it into their schedules (Strampel et al., 2014). As seen in the literature, teachers did not mention current resources available to them, but more so emphasized the need for support in terms of activities, exercises, e-resources, and workshops to assist in proper DPA implementation (Strampel et al., 2014). The lack of resources available to teachers to implement DPA is also problematic. This supports the development of a physical activity based mobile app for the classroom that would provide activities for children, be easy to use, and accommodate small spaces. This app would be a benefit and a possible intervention strategy to increase physical activity levels during school time.

Current Resources Available to Teachers

Unfortunately, there is very little information on effective tools teachers can use for DPA, a gap in the literature. This could be perceived as a barrier, or constraint that contributes to the lack of DPA implementation in schools across Ontario. The reasoning behind the lack of resources for teachers to use during DPA should be investigated. As DPA is an essential component to getting children active during the school day, our research and future study would be beneficial.

Based on the evidence, it can be seen that schools are not promoting DPA involvement to the degree they should be, which should be considered to improve academic performance in students. There has also shown to be a link between increased physical activity during the school day and improvements of academic performance (Trudeau & Shephard, 2008). Additionally, there is very little information on the resources currently available for teachers to use in the classroom, a gap that should be further investigated. Creating an activity based mobile application that decreases prolonged periods of sedentary behaviour during school hours, where children spend the majority of their day, could have great potential in promoting active play to ensure children reach the CSEP guidelines during DPA.

2.8 Barriers and Facilitators Associated With Integrating DPA Into Classrooms and School Systems

As previously stated, DPA is not being implemented into the classroom at the level and frequency it should be as stated in the curriculum guidelines. The reason behind this is important to identify as if it is understood, researchers can develop tools for teachers to use that can assist in reaching guidelines, such as a mobile application. Equally, it is important to consider facilitators to DPA implementation, as they could also be incorporated within an app to assist children in reaching recommended guidelines.

Barriers

In a study by Dube (2015), teachers were interviewed and asked perceived barriers to implementing DPA in the classroom. Dube found four key barriers that were consistent among the teachers interviewed. These consisted of lack of time, space, and training, as well as, interruptions (Dube, 2015). In terms of time, teachers stated they had difficulty fitting in the required curriculum expectations and "could not fathom "giving up" a whole period for a DPA session", a main reason for excluding it from their schedules (Dube, 2015, p. 30). For interruptions, unplanned fire drills, lockdowns, and assemblies could all occur and take up time during the day teachers may have used for a DPA. Lack of space is an environmental constraint that most teachers felt prevented children from properly getting their heart rate up in a safe environment. As weather can be unfavourable and many schools do not allow technology outside, lack of space is perhaps the most inhibiting factor on DPA implementation (Dube, 2015). Teachers also felt they were not comfortable in providing children with activities to do during DPA as they were not trained in DPA activities (Dube, 2015).

Similarly, in an article by Strampel et al., (2014), they also found five major barriers that contribute to a lack of DPA implementation, those being "lack of time due to other curriculum pressures; lack of resources; lack of space; and lack of staff and student "buy-in", as well as pressures of focusing on subjects such as math and language" (Strampel et al., 2014, p. 19). These barriers were identified in two methods, the first being a likert scale ranging from strongly disagree to strongly agree, as well as open ended questions discussing any other potential barriers that were not listed in the likert scale questions. The reasoning behind these barriers was similar to that found in Dube's study. This article also highlighted possible solutions to overcoming these barriers such as, using a whole-school approach to DPA, using exercise videos, and minimizing activities that require equipment and space (Strampel et al., 2014). These are all aspects to consider when designing a physical activity based mobile application for DPA.

The barriers associated with implementing DPA into the classroom that have been identified can all be linked back to the three constraints previously listed. Individual constraints from both the students and teacher can impact the effectiveness of implementing DPA into the classroom. Teachers may not be motivated to spend the time on DPA and likewise, students may not have the attention span to engage in DPA for a minimum of 20 minutes every day (Dube, 2015). In terms of the task itself, students may not have the skill set or ability to engage in specific activities that are MVPA level of intensity and therefore, may not be engaging in the required level of activity for 20 minutes at a time (Dube, 2015). The last constraint, the environment is perhaps the most impactful constraint for this specific condition (Dube, 2015). The space limitation in classrooms allows for little ability of movement. Weather conditions in Ontario also make it difficult to conduct DPA in an outdoor setting (Dube, 2015). The combination of all these constraints could potentially be preventing teachers from engaging in DPA sessions.

As one can see, there are many challenges associated with incorporating DPA into the classroom. It is important to identify and understand these challenges in order to create solutions as the importance of leading a physically active lifestyle is crucial to overall health. Researchers should aim to continue further investigation into the barriers on integrating DPA into the classroom, as well as how to overcome these barriers, this being a gap in the literature.

Facilitators

Studies examining the success rate of DPA implementation in classrooms have identified a number of facilitators. The most frequently mentioned facilitators to DPA implementation were access to resources, and staff and school board support (Allison et al., 2016; Brown & Elliot, 2015). In a study by Brown & Elliot (2015), semi-structured interviews were conducted with teachers (grades one through eight), as well as administration at both individual schools and the school board itself. At the micro level (i.e., individual schools and classrooms), teachers stated that high motivation, level of comfort, and experience with physical activity were important facilitators to successful DPA implementation (Brown & Elliot, 2015). Teachers also mentioned sharing ideas between teachers and support by administration to be major facilitators (Brown & Elliot, 2015). Lastly, teachers added that access to resources and ideas, and specific technology (i.e. tablets) was a major contributing factor to successful DPA implementation within their classrooms (Brown & Elliot, 2015). However, these facilitators could also be seen as barriers, for example a lack of support and motivation (Brown & Elliot, 2015).

At the macro level, described as school boards and the Ministry of Education, teachers mentioned training sessions provided by the school board to assist in proper

DPA implementation were important (Brown & Elliot, 2015). School board support, priority of DPA by the school board, and available funding from the school board for DPA equipment were also found to be major facilitators to proper DPA implementation in the classroom (Brown & Elliot, 2015). Similar to the micro level, a lack of training sessions and financial support can also be seen a barriers, perhaps suggesting barriers and facilitators are connected (Brown & Elliot, 2015). Further information on these facilitators and the effect they can have on DPA implementation should be examined.

2.9 Current Physical Activity Based Mobile Applications Available to the Public

Technology is a platform that may be able to positively impact health even though screen time has been identified as detrimental to health. If technology, such as mobile apps, are used in moderation and to encourage walking and physical activity, it can produce positive health outcomes, such as decreasing the risk of developing obesity and cardiovascular disease (Hurling et al., 2007). We must examine the app market to identify the current apps that are available for physical activity, as well as examine the gaps that exist in the app market. We must then identify what features were and were not effective. This can assist us in informing our app development and ensuring it is evidence-based.

Currently, there is limited literature examining the success rate of mHealth apps for improving health outcomes. A systematic review by Schoeppe et al. (2016) examined 21 studies that targeted physical activity, and 14 of those showed significant health improvements, such as decreases in glucose, cholesterol, and blood pressure levels, a positive effect on body weight, and increases in fitness levels and QOL (Schoeppe et al., 2016). The studies showing health improvements included the use of behaviour change techniques such as goal-setting, self-monitoring, and performance feedback to assist in achieving these improvements (Schoeppe et al., 2016). Further, these applications also utilized gamification techniques such as awards and rewards (Schoeppe et al., 2016). However, the exact effect these studies had on physical activity level has not been examined.

As seen in many systematic reviews and meta-analysis, there are few apps designed for DPA that are also specific to children, while being physical activity based. However, there are many physical activity based apps that are geared for the general population. In a systematic review conducted by Mateo, Granado-Font, Ferré-Grau, & Montaña-Carreras (2015), twelve articles based on physical activity mobile apps were examined. The articles included mainly randomized controlled trials that lasted two weeks to six months in duration. The apps were used as intervention tools to target obesity and weight loss. The studies included a control group and an intervention group. The intervention group used a mobile app as a strategy to increase physical activity levels, and the control group used traditional interventions or intensive counselling. The apps utilized the phone's messaging system to prompt participants about engaging in physical activity, which was found to be an effective technique in increasing activity levels (Mateo, Granado-Font, Ferré-Grau, & Montaña-Carreras, 2015). It was found that, in comparison to the control group, the individuals in the intervention group with the mobile app had significant decreases in body weight and had a pooled estimate of net change in body weight at -1.04 kg (95% CI -1.75 to -0.34; I2 = 41%) (Mateo et al., 2015). There was also found to be a significant net different in BMI in the intervention group, ~ -0.43 kg/m^2 (95% CI -0.74 to -0.13; I2 = 50%) (Mateo et al., 2015). These results indicate positive effects on health when using a mobile application as a physical activity intervention tool.

Similarly, a few other studies conducted systematic reviews to see which apps were available on the Apple Store as physical activity intervention tools and which features they utilized, as well as to test their effectiveness. An example of an app with a significant amount of recommended strategies or behavioural targets that was found to be effective in promoting physical activity was “HyperAnt” (Schoffman et al., 2013). “HyperAnt” provided children with activity cards that gave them ideas on how to be active surrounding health and fitness activities (Schoffman et al., 2013). It provided the children with information while including an interactive piece (Schoffman et al., 2013). Other apps that were recommended were “Lose It!”, a weight-loss app, and “MyFitnessPal”, a counselling app targeting weight-loss. Both of these apps use text messaging systems to prompt users to engage in physical activity (Mateo et al., 2015). These apps use self-monitoring and goal setting as tools to encourage active behaviour. They are effective in engaging users by incorporating ease of use, feedback, functionality, a welcoming design, and ability to customize (Mateo et al., 2015). Unfortunately, the majority of physical activity based apps are focused on weight loss, which is not appropriate for children. Instead, apps should focus on promoting a healthy lifestyle and increasing one’s heart rate to encourage overall health. Therefore, it would be beneficial to create an app which focuses on promoting physical activity to increase one’s overall health and lead a healthy lifestyle while decreasing sedentary periods in a fun and interactive way.

2.10 Effectiveness of Mobile Apps for Increasing Physical Activity and Reducing Sedentary Time

Since the level of physical activity that should be occurring, as well as how much is occurring in children, has been identified, it is important to research and understand the effectiveness of a mobile application for increasing physical activity levels among children while reducing sedentary time. In numerous articles, the effectiveness of mobile applications in increasing levels of physical activity was examined. However, most articles focused on the population as a whole, as there are few studies in the literature that are specific to children.

The majority of the studies examining app effectiveness in increasing physical activity were randomized controlled trials. In multiple systematic reviews, mobile applications that have been developed were examined in order to identify if they were effective in increasing physical activity levels. The researchers specifically examined if applications or active video games (AVG's) that are fun and interactive have the potential to increase MVPA levels (Peng, Crouse, & Lin, 2013; Schoeppe et al., 2016). AVG's can be described as peripheral control devices that encourage physical activity directly by integrating technology with game play to capture the movement of a player, for example, the Wii Fit (Barnett, Cerin, & Baranowski, 2011). The first study in a systematic review showed that out of 13 intervention studies, all suggested that AVG's increase physical activity level when light-to-moderate (Peng et al., 2013). This study also found that only three of the 13 interventions promoted an increase in MVPA (Peng et al., 2013). The second study specifically focused on application use when it was stand alone or multi-component. Multi-component applications include a variety of prompts to encourage individuals to complete a task, such as using reminder messages, timers, calendars, and step counters to track activity levels (Schoeppe et al., 2016). This study found that mobile application interventions could be a feasible tool in increasing activity levels, and that multi-component applications are more effective than stand-alone applications (Schoeppe et al., 2016). One other study found that there was a general consensus that further research was required in this field to understand the possibility of using a mobile application as an intervention strategy (Warburton et al., 2006).

In a randomized controlled trial, similar conclusions were drawn to the previous study (Duncan et al., 2016). Apps were created in order to test their effectiveness in increasing physical activity levels. This article incorporated an accelerometer along with their app, possibly being an additional resource to consider when creating a mobile application for children. The study primarily focused on user-entered data compared to device-entered data (Duncan et al., 2016). The study found that user-entered data may cause extra burden and that it is often incorrect and raises question for bias, indicating that in developing an effective app, information should be input by the device (Duncan et al., 2016). The user-entered data may also be affected by individual constraints that manually inputting data places on the body. Individuals may lack the motivation and attention span to manually input the data.

Another important aspect in effective app design is gamification (i.e., "the use of game design elements in non-game contexts": Groh, 2012, p. 39), or game development features such as a rewards system. There are twelve different elements to gamification which are as follows: gamification concept-to-user communication, user identity, rewards, competition, target group, collaboration, goal-setting, narrative, reinforcement, level of integration, persuasive intent, and user advancement (Schmidt-Kraepelin, Thiebes, Tran, & Sunyaev, 2018). Two different articles examined the impact of gamification on increasing application play adherence and primary engagement. The first study showed both quantified (concepts such as "step counting, and real-time feedback on progress towards goals": Zuckerman & Gal-Oz, 2014, p. 1705), and gamification techniques (concepts such as a virtual rewards system) were equally effective (significance of $p<0.001$) in promoting app engagement in physical activity based apps (Zuckerman & Gal-Oz, 2014). The second article summarized that gamification is an important aspect in increasing behaviour change techniques that can be crucial in promoting a physically active lifestyle (King, Greaves, Exeter, & Darzi, 2013).

In summary, research suggests that mobile applications could increase levels of physical activity, while reducing sedentary time. Most research previously conducted states that further research is required in order to deem this finding as concrete, as it is still a recent intervention option. Also, little research has been conducted on this intervention specifically with children. This observation further encourages the importance of our research and future study.

2.11 Current Mobile Technology Engagement Among Children

In general, mobile applications (apps) and technology are growing fields with large potential. Mobile apps are computer programs that can be run on different devices such as phones and tablets. They can be used to track activity and diet, as a news source, for gaming purposes, as audiobooks, for communication, and many other activities (Techopedia, 2018). Overall, mobile apps can be defined as a form of technology that can be downloaded onto one's phone for many uses such as social media, health promotion, and gaming (Fitzgerald & McClelland, 2017).

Based on findings in the literature, a large majority of the current physical activity based apps are not specific for children or focus on weight reduction and diabetes prevention, rather than physical activity promotion. One study examined mobile apps (n=57) to identify the feasibility of treating and preventing pediatric obesity by promoting a healthy diet and physically active lifestyle among the youth population (Schoffman, Turner-McGrievy, Jones, & Wilcox, 2013). Of the apps examined (n=57), there were 20 that specifically targeted physical activity promotion (Schoffman et al., 2013). This study used specific exclusion criteria to eliminate apps, producing a total of 57 from an original 171, based on factors such as price, user rating, and age rating (Schoffman et al., 2013). Therefore, there could have been many more apps available across multiple platforms that were not considered as they did not fit the price or user age and rating criteria. Unfortunately, this does not give us the total number of physical activity based apps available to children, but it does give insight into the known apps' quality and features, as this study stated the "physical activity promotion apps included the most [behaviour change] recommendations" (Schoffman et al., 2013, p. 322). These recommendations included setting goals and limits, and were integrated in 16 of the 20 apps found (Schoffman et al., 2013). As there is currently minimal information available in the field of physical activity apps for children and the recommendations they utilize to promote physical activity engagement, it would be beneficial to continue conducting studies, as the present generation resolves around technology. A mobile app could be a practical option for increasing physical activity and disrupting sedentary periods among children in and outside of the school environment. One must understand the feasibility of this idea before beginning development.

Of the limited mobile app studies that analyze apps with the aim of increasing physical activity, it has been found that apps are successful in achieving their intended goal. However, these findings are sparse and these studies suggest further research is required to ensure this is an accurate finding, and the reason behind the effectiveness should be identified. In a study by Schoeppe et al. (2016), using a systematic review, 23 studies specific to adults were examined, in which 17 showed health benefits. The review also examined four studies specific to adults, in which two showed health benefits. Of these 27 studies, 21 targeted physical activities and 14 of those showed significant health improvements. Both of the studies that showed health benefits specific to children were specific to targeting physical activity. Further, this review found that the apps that were effective in increasing physical activity levels included multi-component intervention strategies, rather than a stand-alone intervention strategies (Schoeppe et al., 2016). Examples of features that entail an intervention to be multi-component intervention are the use of websites, a pedometer, and physical education (Schoeppe et al., 2016). Based on these findings, further research should be conducted on physical activity based apps for children to identify what features increase physical activity levels.

Both the App (herein referred to as Apple) and Google Play Store are platforms that contain a large variety of mobile apps for individuals of all ages. These include categories such as health and fitness, kids, games, and sports. The mHealth apps found within these two stores can also be found among various research studies in the literature which can be useful for studies similar to ours, as they analyze apps to inform researchers on information such as step counts, frequency of activity, and level of activity, all of which are important to consider when researching physical activity involvement (Techopedia, 2018). Whether using a mobile device or tablet, children can access and download mHealth apps from these platforms with ease and use them to increase activity level. As the current generation relies heavily on technology in their daily lives, with 46% of the adolescent population aged nine to 16 years having a mobile device of their own or access to one (Mascheroni & Ólafsson, 2016), mHealth could be beneficial to explore in terms of increasing physical activity levels among children. However, in order to understand the feasibility of using mHealth as an intervention for increasing physical activity, we must identify what mobile apps are currently available in this field and the current level of mHealth app engagement among children.

Children are drawn to fun and interactive games, and mobile apps have become commonly used among children, even at a very young age (Lieberman, 2006). It was found, when conducting a survey with 1,043 parents of children, that apps in the *games category* were "the most popular type of app downloaded on mobile devices used by children, with the average device containing approximately 10 game-related apps" due to their interactive qualities (Chiong & Schuler, 2010, p. 10). This survey was designed to target parents of children aged zero to 14 and was conducted in 2010 when mobile apps were moderately new (Chiong & Schuler, 2010). The results from this study showed that the most common apps amongst child users are game related apps. This is important to consider when developing an app targeting DPA.

2.12 Behaviour Change Techniques Integrated Within Mobile Apps to Increase Movement Behaviours

In order to increase levels of physical activity in an individual and remove any current unhealthy behaviours, behaviour change techniques must be considered. Behaviour change is a technique that promotes a change in behaviour, typically in a positive and desired direction (Direito et al., 2014). This concept is critical when adopting difficult lifestyle changes, such as changing from inactive to active. In order to organize the techniques, a taxonomy was created. This taxonomy consists of 93 techniques which were groups into 16 specific sections by Michie et al., (2013). The 16 categories are as follows: goals and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour, associations, repetition and substitution, comparison of outcomes, reward and threat, regulation, antecedents, identity, scheduled consequences, self-belief, and covert learning (Michie et al., 2013).

Multiple articles examined the most beneficial behaviour change techniques in not only mobile applications, but also in increasing physical activity levels in general. There are many behaviour change techniques that can be used, but some are more effective in certain populations over others. One article by Brannon and Cushing (2014) found that modelling was an effective technique to predict physical activity in children aged six to 13 years (Brannon & Cushing, 2014). Modelling can be described as providing an example for people to use a reference such as pictures or videos (Michie, Van Stralen, & West, 2011). This technique was incorporated in 124 physical activity apps (Schoeppe et al., 2017). This study also found that the use of instruction was a beneficial technique for increasing physical activity levels in children. There were a total of 131 apps that incorporated this technique (Michie et al., 2011).

Two other articles found that the most effective behaviour change techniques used to increase movement behaviour are: self-efficacy, social norms, outcome expectancies, goal setting, self-monitoring, feedback, providing instruction, and set graded tasks (Goran & Reynold, 2005; Lyons, Lewis, Mayrsohn, & Rowland, 2014). It was found that these behaviour change techniques are the root cause behind an effective intervention in increasing physical activity levels among children under the age of 18 years, similar to constraints shaping the development of a movement (Goran & Reynold, 2005; Lyons et al., 2014).

In order for an effective application to be created, behaviour change techniques are a requirement as well as understanding which behaviour change techniques should be implemented over others, and why they should be. The behaviour change techniques that are effective in increasing movement behaviour have been identified, but tools that supplement these techniques are required.

2.13 Other Important Considerations

Just as it is important to identify the current level of activity in children and identify barriers that prevent implementation of DPA in the classroom, it is important to consider other aspects such as access to technology in the classroom and socio-economic status in different areas across Ontario. Researchers must identify and understand the impact these factors can have on physical activity engagement as these could impact students involvement in physical activity both at and outside of the school environment.

As it has already been established, many children have access to a smartphone (Mascheroni & Ólafsson, 2016). As children are not allowed smartphones in class, the technology to use a mobile app would have to be supplied from the school. This could be in the form of a laptop, desktop computer, or a tablet device (iPad or Samsung as both are the most popularly used devices and contain the highest quality apps) (Ranger, 2015). Depending on the location of the school, it could be possible that they may not have funding for such technology, or may have limited access to these items (Looker & Thiessen, 2003). This does not make it ideal for the development of a mobile application to be used for physical activity.

In an article by Ertmer (2015), though not specific to Canada, but rather the United States, it was found that "81% of teachers have either moderate or high levels of access to instructional computers", and this was not impacted by poverty levels (Ertmer, 2005, p. 25). This could be different in Canada though as it is a different economy. This article is also outdated as it is centered around computers and before tablets were developed. Unfortunately, little research has been conducted in this area since.

Though not specific to Canada or Ontario, in a study by Purcell, Heaps, Buchanan, and Friedrich, through an online survey with teachers, they found that 70% of teachers in high socio-economic areas stated that their school did a "good job" in providing technology to use in the classroom, while only 50% of teachers said the same in lower economic status areas, a difference of 20% (Purcell, Heaps, Buchanan, & Friedrich, 2013). In addition, the same study found that 56% of teachers stated their students used tablet computers for learning in higher economic statuses, while in lower economic statuses, only 37% teachers found this (Purcell et al., 2013).

2.14 Conclusions

Based on the evidence presented in the literature, a mobile application could be effectively used to increase movement behaviour and decrease sedentary time among school aged children. Previous research has highlighted the importance of physical activity in children, and has emphasized the lack of physical activity among this population. Children are not reaching the guidelines, which can negatively impact their health and well-being.

Previous studies have shown that mobile applications are an effective way of increasing physical activity, and applications that incorporate an element of behaviour change tend to yield the greatest adherence (Goran & Reynolds, 2005; Lyons et al., 2014). Concepts such as gamification can also make an application interactive and fun, without creating distraction from the educational concepts, but further research on these subjects would be beneficial, specific to physical activity based apps, as this is a current gap.

Researchers should be attentive to the constraints that have been outlined in terms of the implementation of DPA. When designing an app, researchers should attempt to overcome these constraints and fit the needs of both the teachers and the students. Researchers should also be conscious of the access to technology as, if schools in a specific area do not have access to tablets, a mobile application would not be useful to them.

In addition, researchers should attempt to examine and identify the individual, task, and environmental constraints throughout all aspects of research they study. This can be a useful tool in understanding the feasibility of a concept, as well as understanding what may be inhibiting this concept from occurring.

Based on the previous findings and the gaps that have been identified, research is needed to inform the development of an app targeting DPA. In particular, an environmental scan and focus group interviews are required before developing an app. These studies will assist us in gaining a better understanding of the app market, specifically what apps are currently available for teachers to use in the classroom for DPA that are age appropriate. Further we will identify the resources teachers are currently using in the classroom, as well as better understand the constraints of the classroom and teachers' interest in an mHealth solution.

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Chapter 3.

Examination of the App Market: An Environmental Scan of Physical Activity Mobile Apps Available for Children and the Classroom

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3.1 Introduction

Physical activity is defined as activity that engages skeletal muscles and raises energy expenditure above the resting level (Caspersen, Powell, & Christenson, 1985). Physical activity can be performed at various intensities such as low, moderate, and vigorous (Tremblay et al., 2011). It has been well documented that physical activity has a positive effect on overall health and well-being of individuals, such as decreased risk of developing cardiovascular disease and obesity, regardless of age (Maher et al., 2013). Physical activity has been shown to increase quality of life (QOL), decrease the rate of morbidity and mortality, and decrease the risk of developing diabetes and cardiovascular disease (Maher et al., 2013), among children. Engaging in physical activity is also associated with increased success in school as it aids children with developing proper motor skills and self-efficacy, and increasing concentration and focus (Warburton, Nicol, & Bredin, 2006; Sigman, 2012).

In order to achieve the health benefits of physical activity, the CSEP recommends that children between the ages of five to 17 should perform a minimum of 60 minutes of moderate-to-vigorous level activity (MVPA) should be accumulated in a single day (Colley et al., 2011). Unfortunately, children are not achieving these recommendations. In fact, Canadian youth spend on average 8.6 hours per day, or 62% of their waking hours in a sedentary state, with only 9% of males and 4% of females accumulating 60 minutes of MVPA per day at least six days a week, meeting the guidelines (Colley et al., 2011). This is a concerning as sedentary behaviour is associated with many negative risks to health.

Sedentary time is defined as “a distinct class of behaviours (ex., sitting, watching TV, driving) characterized by little physical movement and low energy expenditure” (Tremblay et al., 2010). Accumulating sedentary time may be independently associated with health risk in children. A cross-sectional study in Portugal examined 12 year old males (n=5,000) and found that for every hour spent being sedentary per day, children were 32% more likely to be obese (Sardinha et al., 2008). Thus decreasing sedentary time is also a priority for the health and well-being of children.

Unfortunately, children spend many hours a day seated in the classroom, and are unable to obtain much physical activity throughout the school day. A solution that was mandated in Ontario classrooms in 2006 was Daily Physical Activity (DPA). DPA is a mandatory policy that was implemented with the intent of increasing the current level of activity for children during the school day (Stone, Faulkner, Zeglen-Hunt, & Bonne, 2012). It was mandated to be 20 minutes in duration and there are no limitations or set rules regarding the type of activity that should be performed (Stone et al., 2012). As such, DPA can include fun activities that can increase heart rate and engage skeletal muscles (Allison et al., 2014).

As DPA is open-ended and teachers are provided with little resources, as such a tool that teachers could use to increase activity levels in children may be beneficial (Robertson-Wilson & Lévesque, 2009). As technology is becoming increasingly popular worldwide, especially among children, a physical activity based mobile application (app) could be a viable option (Stone et al., 2012). This app would be required to be easy to use and quick to set up.

Developing such an app may be complex since typically when one plays a "game" on their phone or tablet through a mobile application they are in a sedentary/seated position. This would defeat the purpose of an app aiming to increase activity. But, an app for DPA could be a resource for teachers, which currently there are very little of. As some teachers are not primarily trained in physical education, creating fun activities that increase activity levels during DPA can be difficult. Having a readily available resource that is easy to use would assist in supporting teachers during DPA, while increasing physical activity levels of children.

The purpose of this study was to identify the apps that are currently available for children to use to increase activity levels on both the Apple and Google Play Store by conducting an environmental scan. Environmental scans are a process often used to collect information about products, processes outcomes and future directions (Marcus, 2018). In this study, the environmental scan will aim to examine the app market to identify the mobile apps available to children that teachers could use within the classroom, which had the goal of increasing physical activity, as well as identify the current gaps in the app market (i.e., mobile health: mHealth) (Facer et al., 2004). Findings will ultimately assist us in informing the creation of a mobile application that can be used in the classroom during DPA to increase student's physical activity levels in a fun and interactive way. We wish to answer the following research questions with this environmental scan:

- What types of physical activity mobile apps are available for teachers to use in the classroom during DPA?

- What applications are available to increase physical activity? What are the effective behaviour change and gamification techniques used in these applications?

3.2 Methodology

Sources of Information, Selection and Coding Procedure

The environmental scan for this study was conducted on both the Apple and Google Play Stores commencing on May 24th, 2018, and concluding on October 18th, 2019, and it followed five specific stages. Each stage had its own specific inclusion or exclusion criteria to ensure that only appropriate apps were retained for analyses. As there were no specific protocols to follow when conducting an environmental scan, we used the PRISMA checklist (Moher, Liberati, Tetzlaff, & Altman, 2009) as a guide to ensure this process was organized and that no major components were omitted. The PRISMA Checklist can be found in Appendix B1 (Appendix B1). Note that not all PRISMA sections/topics applied to this study and were omitted when appropriate. In order to present this change, a customized and updated version of the PRISMA Checklist (Quasi-PRISMA) we used can be found in Appendix B2 (Appendix B2).

This environmental scan followed a specific protocol, consisting of five different stages (see Table 1). These stages included a search of the Apple Store and Google Play Store, merging the contents of both stores, app elimination based on app title and specific criteria, app elimination based on app description and specific criteria, and finally, downloading and assessing apps.

Stage of Protocol	Description of the Stage
1	Search of the Apple Store and Google Play Store using specific key terms.
2	Merging the contents of both stores onto a separate sheet to create a grand total of apps across both stores.
3	App elimination based off of title of app and specific criterion.
4	App elimination based off of app description and specific criterion.
5	Downloading and assessment of apps based off of four factors that informed the content of our app. • Behaviour change techniques, gamification techniques, mobile app rating scale (MARS), user reviews and ratings.
App = mobile application	

Table 1. Five Stages of Protocol

First, for Stage 1, the process of searching and collecting the data was the same for both stores. A researcher used all nine search terms (see Table 2) and individually put each in the search function of the store. The researcher then recorded the name, developer, and cost of each app that appeared in a Google sheet. To ensure there were no changes in the app list that appeared when using a search term, the researcher completed the search of one term in a single seated period, rather than over a few days. This is because the app store had additions and substitutions every day. The researcher completed the search of different terms over multiple days, but completed the search of a specific single term in one sitting. The researcher added all apps found per search as this ensured all potentially relevant apps for our study were found.

Key Terms for Apple and Google Play Store Search								
Physical education	Kids fitness	Child fitness	Kids exercise	Child exercise	Fitness game	Exercise game	Physical activity	Children sports

Table 2. Specific Key Terms for Search

Second, for Stage 2, once the total number of apps for each store was established, and all duplicates were deleted, a new Google sheets document was created with a tab labelled “Merged Stores” containing the search results from both app stores. The apps were sorted in alphabetical order, which highlighted if the same app existed between both stores. If this was the case, one of the duplicates was deleted and the other was highlighted yellow to signify the app was found on both stores.

Third, for Stage 3, once all apps identified with the nine terms were added to a Google sheet and had been sorted, merged, and duplicates had been deleted, the relevance of the app was determined based on the exclusion criterion in Table 3 (Stage 3). The exclusion criterion was based solely on the title of the app (Table 3).

Code	Reason
0	Service Provider/Retailer
1	Information not relevant for children
2	No physical activity content
3	Title indicates adult population
4	App not in English
App = mobile application	

Table 3. Exclusion Criterion for Stage 3 Using App Title Only

As one can see, there were five exclusion criterion, coded from zero to four. If the app contained one of these five criterion, it was excluded. The criteria being applied deemed the apps as either “potentially relevant” or “not relevant”. The apps that were deemed potentially relevant were retained, while the apps that were deemed not relevant were subsequently deleted from the Google sheet and put onto a separate tab for tracking purposes.

Fourth, for Stage 4, a more specific exclusion criteria was applied. For this stage, the exclusion criteria was based off of the description of the app, as well as information provided, such as the age rating and date of last update. The full exclusion criteria that was applied for Stage 4 can be seen in the table below (Table 4). A table of all the inclusion and exclusion criteria used throughout the scan can be found in the table below (Table 5). The final app list was the last stage and included downloading and assessing the content of the apps (Stage 5).

Code	Reason	Example
0	Service Provider/Retailer	Gyms, Nike, FitBit
1	Information not relevant for children	Colon cancer, pregnancy, baby physical activity/health apps that target parents
2	No physical activity content	Sexual health, sleep, mental health, strictly nutrition
3	Apps with inappropriate age rating	12+ and 17+ in App Store, Teen or Mature in Play Store
4	Specified population/user group	Users must of had access code, been patients at a specific clinic etc.
5	Simple tracker	ONLY tracked steps and/or weight loss, no other form of interactivity or education. Apps that were only for logging/tracking workouts. Apps that used challenges, leaderboards, ability to interact with friends were INCLUDED
6	Physical activity content is not relevant	Word searches and colouring books and quizzes. App played sport arcade style, but did not get you moving
7	No update after January 1st 2016	App was last updated on January 1st, 2016
8	Not in English	App was in a different language such as Spanish, French, etc.
9	Other	Could not find, did not meet inclusion criteria, issue specified in comments
App = mobile application		

Table 4. Exclusion Criterion for Stage 4 Using App Description and Features

Inclusion Criteria	Key Terms (Stage 1)	Exclusion Criteria	Code	Reason	Example
	Physical education		0	Service Provider/Retailer (Stage 3 & 4)	Gyms, Nike, FitBit
	Kids fitness		1	Information not relevant for children (Stage 3 & 4)	Colon cancer, pregnancy, baby physical activity/health apps that target parents
	Child fitness		2	No physical activity content (Stage 3 & 4)	Sexual health, sleep, mental health, strictly nutrition
	Kids exercise		3	Title indicates adult population (Stage 3) Apps with inappropriate age rating (Stage 4)	Men, women (Stage 3) 12+ and 17+ in App Store, Teen or Mature in Play Store (Stage 4)
	Child exercise		4	Not title in English (Stage 3) Specified population/user group (Stage 4)	App title was in a different language such as Spanish, French, etc. (Stage 3) Users must of had access code, been patients at a specific clinic etc. (Stage 4)
	Fitness game		5	Simple tracker	ONLY tracked steps and/or weight loss, no other form of interactivity or education. Apps that were only for logging/tracking workouts. Apps that used challenges, leaderboards, ability to interact with friends were INCLUDED
	Exercise game		6	Physical activity content is not relevant	Word searches and colouring books and quizzes. App played sport arcade style, but did not get you moving
	Physical activity		7	No update after January 1st 2016	App was last updated on January 1^{st}, 2016
	Children sports		8	Not in English	App was in a different language such as Spanish, French, etc.
			9	Other	Could not find, did not meet inclusion criteria, issue specified in comments

App = mobile application

Table 5. Complete Set of Inclusion and Exclusion Criteria Throughout All Stages of Scan

As one can see, there were nine criterion/codes. Codes zero to two and code eight were repeated from Stage 3 as these codes may have not been relevant based just on the title of the app, but became evident when reading the app description and details. Therefore, there were only six exclusion codes that were new to this stage, those being three to seven and nine. Apps were not included if they had not been updated since January 1st 2016 as many are no longer compatible with devices and had outdated content. Apps were also not included if they were a “play” or “arcade” style as this only included users tapping the screen while in a sedentary position, rather than users being in an active state. When applying the codes, it was based on whether we were to “include” or “exclude” the apps from the final assessment and analysis phase. Similar to Stage 3, the apps that were found to be excluded in the final assessment stage were deleted from the Google sheet and put onto a separate tab for tracking purposes.

Lastly, apps were excluded by one further criterion which examined specific terms and concepts found within the title, such as “weight loss, yoga, and tracker”. Apps were also further excluded if they were of a price higher than $9.99. The full criterion can be found in the document labelled “Final Exclusion Criteria” in the Appendix below (Appendix B3).

Data Extraction, Evaluation Criteria and Instruments

We extracted the app name, developer name, cost, average ratings, and total ratings from the Apple and Google Play Store databases. For our final stage, Stage 5, we examined the behaviour change techniques, gamification techniques, Mobile App Rating Scale (MARS), and user reviews and ratings for each app, with information that can be seen summarized in the table below (Table 6).

Category	Source	Example/Analysis Feature
Behaviour Change Techniques	The behaviour change taxonomy consisting of 93 techniques and Behaviour Change Techniques for Health Apps by Conroy, Yang, and Maher, 2014.	Include providing instruction on how to perform behavior, modeling/demonstrating the behavior, providing feedback on performance, goal-setting for behavior, planning social support/change, information about others' approval, and goal-setting for outcome. These were the most common BCT's found in health apps.
Gamification Techniques	Based on the Gamification Taxonomy outlined by Schmidt-Kraepelin, Thiebes, Tran, and Sunyaev, 2018.	Includes the following 12 domains with their specific characteristics: direct (gamification concept-to-user communication), visual character (user identity), internal and external (rewards), direction (competition), target group (healthy individuals), cooperative (collaboration), externally set (goal setting), episodical (narrative), positive (reinforcement), inherent (level of integration), behaviour change (persuasive intent), and presentation only (user advancement).
Mobile App Rating Scale (MARS)	Based on the MARS Scale (Stoyanov, Hides, Kavanaugh, Zelenko, Tjondronegoro, and Mani, 2015).	Includes the following four sections: engagement, functionality, aesthetics, and information. MARS uses a 5 point system with 1= Inadequate, and 5= Excellent. This scale provides a score per domain to provide a reliable quality score of apps.
User Reviews and Ratings	Stars or ratings and the written user reviews on the Apple and Google Play Store.	App star ratings will provide us with a subjective app rating from a user perspective. Written user reviews will be used to provide suggestions for change and additions to our app.
App = mobile application		

Table 6. Assessment Categories for Final Stage of Protocol

Behaviour Change Techniques

We examined behaviour change techniques (BCTs) as they are an effective way of encouraging and producing a desired behaviour, which is useful in the field of physical activity (Warburton, Nicol, & Bredin, 2006). In order to ensure we were properly certified in identifying the presence of BCTs within apps, researchers completing this scan completed the Behaviour Change Taxonomy Training. A copy of the certificate can be found in the appendix (Appendix B4). BCTs that encouraged individuals to increase activity were beneficial to us and therefore, it was important for us to identify which BCT's existed in the included apps. A checklist was created to highlight which BCT's were included within the apps. Once all apps were analyzed, we as researchers identified which BCT's were most commonly found among physical activity based apps and compared our results to those found in the Conroy, Yang, and Maher, (2014) paper.

Gamification Techniques

Similarly, gamification techniques, or rewards systems, are used to encourage participation, which can be useful for increasing physical activity (Brannon & Cushing, 2014). Using a taxonomy of gamification techniques in the literature that has been reviewed for effectiveness, we examined which apps from our environmental scan included these beneficial techniques. Some of the domains in the taxonomy included the app incorporating user identity, rewards, competition, collaboration, and reinforcement. We also further identified the characteristics of these domains, such as the use of internal or external rewards, or neither.

Mobile Application Rating Scale (MARS)

It is also important to assess the quality of the apps. In order to ensure we were not assessing the quality of the apps in a subjective manner, we used the Mobile App Rating Scale (MARS). The MARS scale is a validated tool that assesses the overall quality of an app using four sections. Previously, there was no other way of assessing app quality other than "star" ratings provided by app users (Stayonav et al., 2015). The MARS scale consists of the following sections: A. Engagement, B. Functionality, C. Aesthetics, and D. Information, which contained 23 subcategories (Stayonav et al., 2015). In each section researchers assigned a rating of one to five, one being inadequate and 5 being excellent, producing a score for each section (Stayonav et al., 2015). The scores for each section were averaged individually, as well as added altogether and averaged to see the mean score out of five to provide an overall quality assessment. This processes was completed for each section by two researchers in order to identify an inter-rater reliability score. The MARS Scale can be found in the appendix (Appendix B5).

Interrater Reliabilities

In order to ensure accuracy in our selection process, we utilized a third reviewer. This reviewer was the deciding factor when there was a disagreement between the first two reviewers (the third reviewer was blinded to the decision either of the first two reviewers made in terms of inclusion and exclusion). Similarly, ordinal and nominal Krippendorf's alphas were used to examine inter-coder reliability between two reviewers for Stage 5 results. Reliability estimates below .70 were discussed and resolved through discussion.

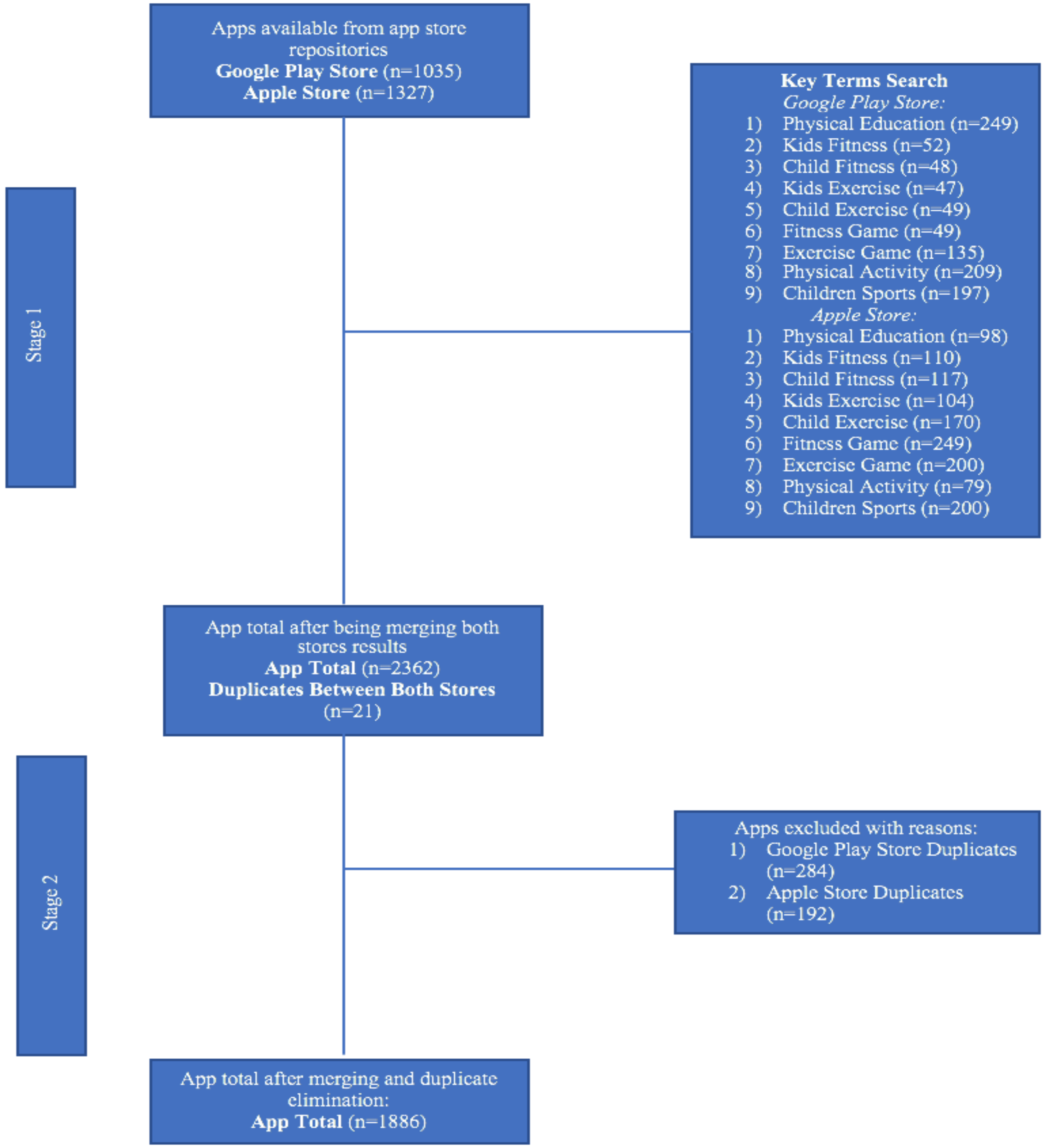
Analysis

At the end of Stage 5, we conducted descriptive analysis. This included examining the app cost, average rating, number of ratings, and number of downloads. Further we examined the descriptive characteristics between app quality and the presence of behaviour change, and gamification techniques.

3.3 Results

Database Filtering and Screening Results

Following the search of the specific key terms in Stage 1, there was a total of 1,329 apps on the Apple Store and 1,035 apps on the Google Play Store (Stage 1). The number of apps that were found for each specific key term in each respective store can be seen in the figure below (Figure 1). After merging the apps together and deleting all duplicates there were a total of 1,886 apps, 1135 from the Apple Store and 751 from the Google Play Store (Stage 2). Following the exclusion of apps based on a specific criteria, detailed in Figure 1, there was a total of 1014 apps (Stage 3), 505 for the Apple Store and 509 for the Google Play Store. Following the exclusion of apps based on a further criteria (see Figure 1 for details), there was a total of 130 apps (Stage 4), 57 for the Apple Store and 73 for the Google Play Store. Based on the final exclusion, which was specific to ensuring the apps were age appropriate, there was a final app sample of 32 apps, 21 for the Apple Store and 11 for the Google Play Store. Note that three more apps (found on both stores) were further deleted once downloading of apps commenced as they were no longer available on the platform to produce a new total of **29 apps**.


Apps available from app store repositories
Google Play Store (n=1035)
Apple Store (n=1327)
Key Terms Search
Google Play Store:
1) Physical Education (n=249)
2) Kids Fitness (n=52)
3) Child Fitness (n=48)
4) Kids Exercise (n=47)
5) Child Exercise (n=49)
6) Fitness Game (n=49)
7) Exercise Game (n=135)
8) Physical Activity (n=209)
9) Children Sports (n=197)
Apple Store:
1) Physical Education (n=98)
2) Kids Fitness (n=110)
3) Child Fitness (n=117)
4) Kids Exercise (n=104)
5) Child Exercise (n=170)
6) Fitness Game (n=249)
7) Exercise Game (n=200)
8) Physical Activity (n=79)
9) Children Sports (n=200)
Stage 1
App total after being merging both stores results
App Total (n=2362)
Duplicates Between Both Stores (n=21)
Stage 2
Apps excluded with reasons:
1) Google Play Store Duplicates (n=284)
2) Apple Store Duplicates (n=192)
App total after merging and duplicate elimination:
App Total (n=1886)

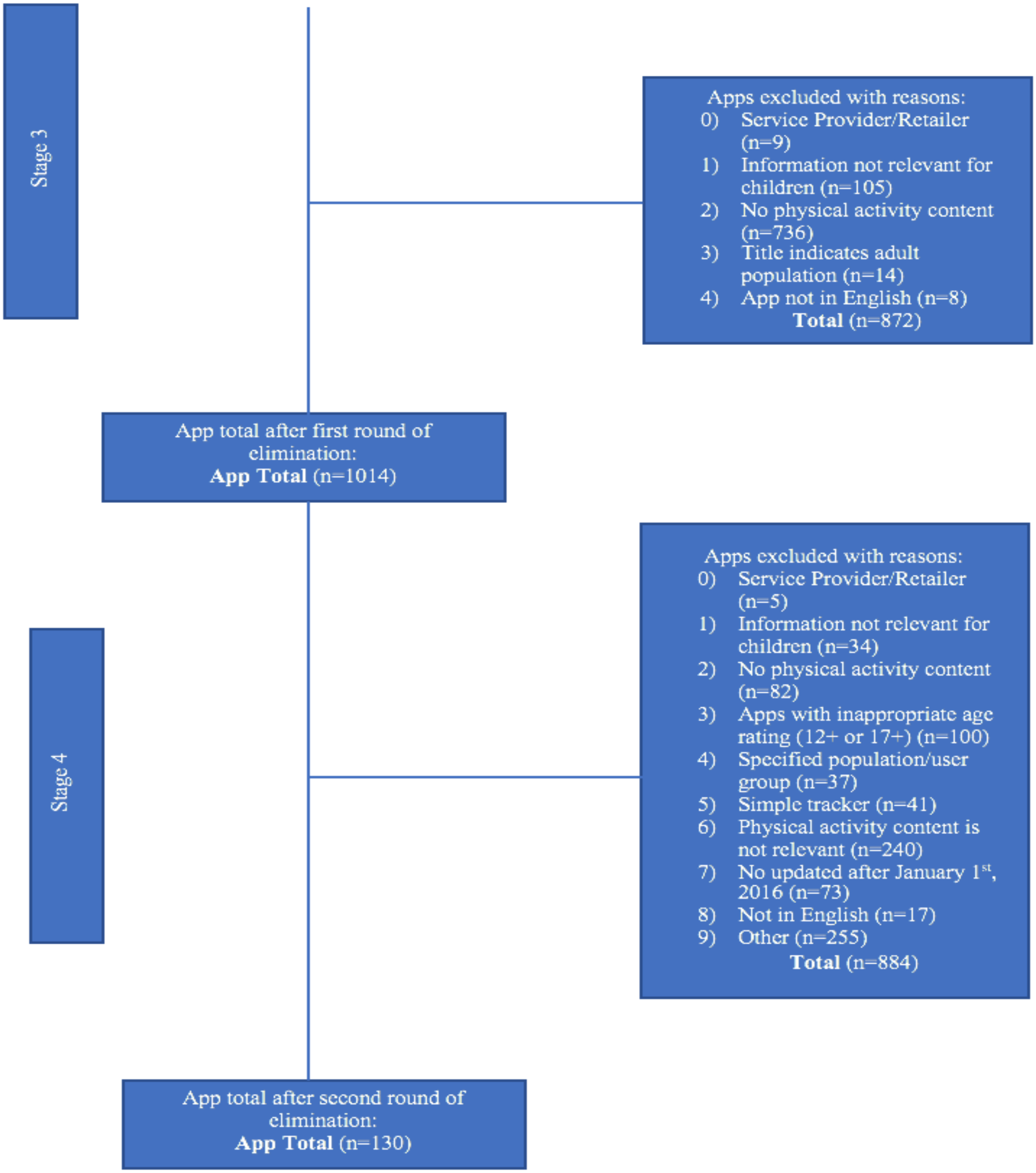

Stage 3
Apps excluded with reasons:
0) Service Provider/Retailer (n=9)
1) Information not relevant for children (n=105)
2) No physical activity content (n=736)
3) Title indicates adult population (n=14)
4) App not in English (n=8)
Total (n=872)
App total after first round of elimination:
App Total (n=1014)
Stage 4
Apps excluded with reasons:
0) Service Provider/Retailer (n=5)
1) Information not relevant for children (n=34)
2) No physical activity content (n=82)
3) Apps with inappropriate age rating (12+ or 17+) (n=100)
4) Specified population/user group (n=37)
5) Simple tracker (n=41)
6) Physical activity content is not relevant (n=240)
7) No updated after January 1st, 2016 (n=73)
8) Not in English (n=17)
9) Other (n=255)
Total (n=884)
App total after second round of elimination:
App Total (n=130)

Figure 1. Flow Chart of the App Elimination

General Characteristics of the Selected Apps

A table with general descriptive data can be found below, summarised in Table 7. Of the 29 apps, all on the Google Play Store (n=9) were free. Therefore, of the apps (n=29), most were free (22/29, 75.8%), while only a few required a cost (7/29, 24.1%). Further, the apps that did require a cost on average were $6.99. Based on reviews out of a score of five, the median user rating score was 4.4 on the Apple Store (8/20 apps included a rating, 40.0 %), and 4.2 on the Google Play Store (9/9 apps included a rating, 100%). The other apps did not include any app ratings (12/29, 41.4%). The top rated apps were *Push2Play* and *Wokamon* for the Apple Store, both receiving a score of five out of five. It is important to note that these apps both only had one rating, differing from an app such as *Walkr - A Gamified Fitness App* which has a score of 4.5, but has a total of 505 ratings. The top rated were *Fitness Sense 2.0* and *TopYa! Active* for the Google Play store, receiving a score of 5.0 and 4.7 respectively. It is also important to note that these apps had fewer ratings (13 and 200) than apps such as *Magic Kinder Official App - Free Kids Games* which had a score of 4.0, but 76,726 ratings. Most apps were two dimensional (27/29, 93.1%), while a few utilized augmented and virtual reality (2/29, 6.9%). There did not appear to be a difference between paid and free apps in terms of score, user ratings, reviews, or number of downloads.

App Name	Price	Store	Score	Number of Ratings	Reviews	Number of Downloads	Age Rating
5-2-1-0 Kids! powered by Henry Ford LiveWell	Free	App Store	N/A	N/A	No	N/A	4+
7 minute workouts with lazy monster PRO: daily fitness for kids and women	$6.99	App Store	N/A	N/A	No	N/A	4+
AIMS - Improving Motor Skills	$6.99	App Store	N/A	N/A	No	N/A	4+
AR Runner	$1.39	App Store	4.4	24	Yes	N/A	4+

Fitness RPG - Gamify Your Pedometer	Free	Both	4.2	3,446	Yes	100,000+	Everyone
Fitness Sense 2.0	Free	Google Play Store	5.0	13	Yes	100+	Everyone
Fun fitness for kids	Free	Google Play Store	3.1	108	Yes	10,000+	Everyone
GeoPlay	Free	App Store	N/A	N/A	No	N/A	4+
GoNoodle Kids	Free	App Store	4.0	137	Yes	N/A	4+
Gorilla Workout: Build Muscle	$1.39	App Store	4.6	27	Yes	N/A	4+
Jump In the Exercise Board Game	Free	App Store	N/A	N/A	No	N/A	4+
KID-FIT Music	Free	App Store	N/A	N/A	No	N/A	4+
Kids Dance PirateSessa: Castle	$6.99	App Store	N/A	N/A	No	N/A	4+
Kids Dance PirateSessa Dungeon	$6.99	App Store	N/A	N/A	No	N/A	4+
Kids Exercise - Animal Workout	Free	App Store	N/A	N/A	No	N/A	4+
Kung Fu for Kids	Free	Both	4.3	21	Yes	1,000+	Everyone (Ages 9-12)
Magic Kinder Official App - Free Kids Games	Free	Google Play Store	4.0	76,726	Yes	5,000,000+	Everyone
Map Monsters: Poke, Swipe, and Go	Free	App Store	5.0	1	Yes	N/A	9+
NFL PLAY 60	Free	App Store	4.0	4	Yes	N/A	4+
Physical Therapy For kids	$9.99	App Store	N/A	N/A	No	N/A	4+
Push2Play - Active Games for Kids	Free	App Store	5.0	1	Yes	N/A	4+
Skipping Skills	Free	App Store	N/A	N/A	No	N/A	4+
Soccer Exercises for Kids	Free	Google Play Store	4.3	642	Yes	50,000+	Everyone
Sworkit Fitness – Workouts & Exercise Plans App	Free	Both	4.1	110,479	Yes	5,000,000+	Everyone
TopYa! Active	Free	Both	4.7	200	Yes	5,000+	Everyone
VR Fitness Sapporo	Free	Both*	N/A	N/A	No	N/A	4+
Walkr - A Gamified Fitness App	Free	App Store	4.5	505	Yes	N/A	4+
Walkr: Fitness Space Adventure	Free	Google Play Store	4.4	63,928	Yes	500,000+	Everyone
Wokamon - Fitness Game	Free	App Store	3.8	32	Yes	N/A	4+
*** = Appeared on both stores originally but now is only located on the Apple Store, therefore it was downloaded from the Apple Store**							

Table 7. General Descriptive Data of Apps

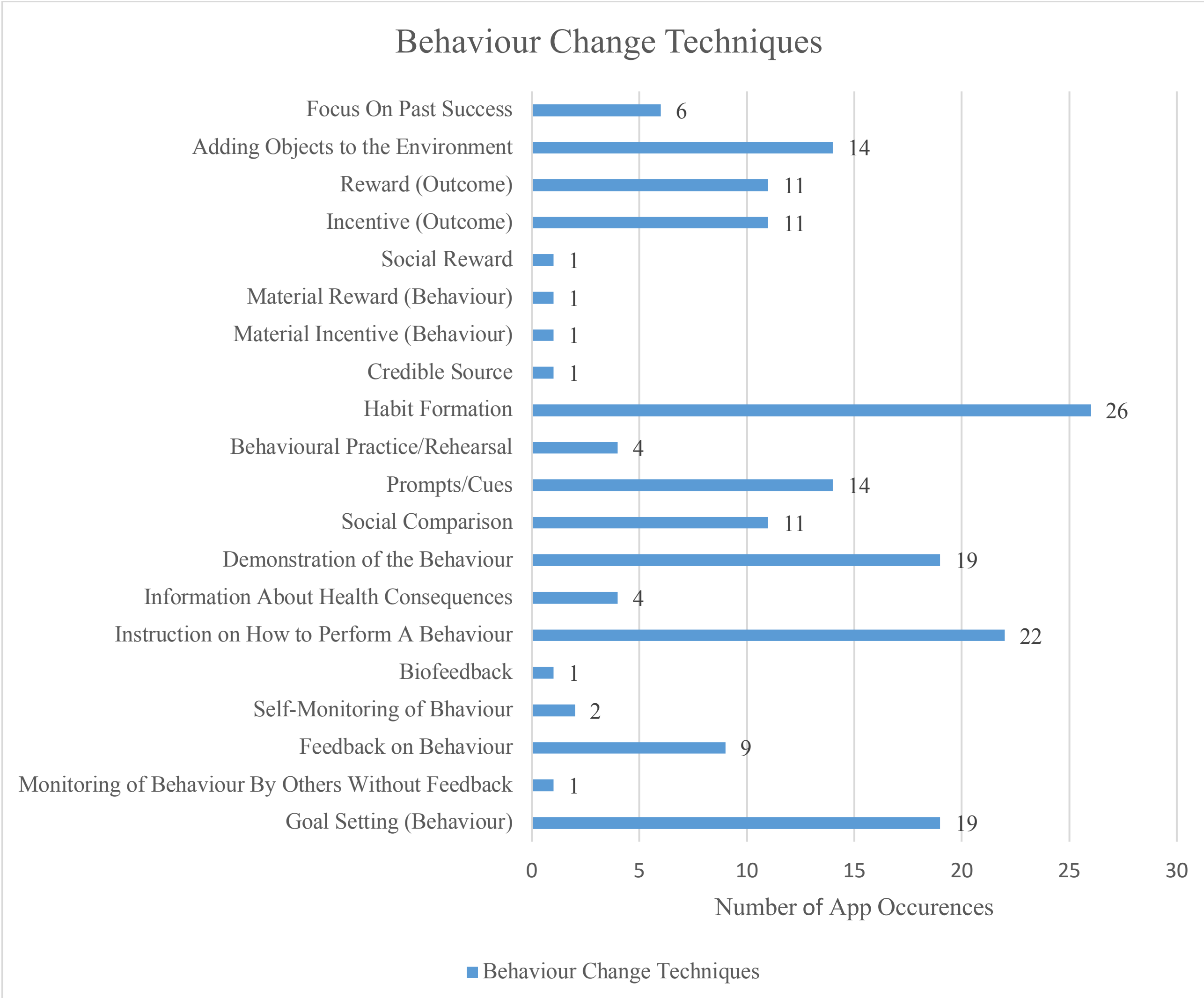
Behaviour Change Techniques

The average number of behaviour change techniques that were included per app was six, ranging from a minimum of one in the app *KID-FIT Music* to a maximum of 13 in the app *TopYa! Active*. Of the 93 techniques listed in the taxonomy, 20 were found across the 29 apps. The top six most commonly utilized techniques were “Habit Formation” (26/29 apps, 89.7%), “Instruction on How to Perform A Behaviour” (22/29 apps, 75.9%), “Goal Setting” (19/29 apps, 65.5%), “Demonstration of the Behaviour” (19/29, 65.5%), “Prompts/Cues” (14/29 apps, 48.3%), and “Adding Objects to the Environment” (14/29 apps, 48.3%). Of the techniques included, the 6 least commonly utilized techniques were “Monitoring of Behaviour By Others Without Feedback”, “Biofeedback”, “Credible Source”, “Material Incentive (Behaviour)”, “Material Reward (Behaviour)”, “Social Reward” (1/29 apps, 3.4%). The specific techniques and there occurrence within apps can be further found in Table 8 located below and in the Appendices (an expanded version including all apps). A figure summarizing this data can also be found below (Figure 2).

App Name	BCTs Utilized	Total BCTs Utilized	Gamification Included?	Gamification Techniques	MARS Section A (Engagement)	MARS Section B (Functionality)	MARS Section C (Aesthetics)	MARS Section D (Information)	MARS Total Score
5-2-1-0 Kids! powered by Henry Ford LiveWell	1.1 Goal Setting (Behaviour) 4.1 Instruction on How to Perform A Behaviour 5.1 Information About Health Consequences 6.1 Demonstration of the Behaviour 6.2 Social Comparison 7.1 Prompts/Cues 8.1 Behavioural Practice/ Rehearsal 8.3 Habit Formation	**8**	**Yes**	1. Gamification Concept–to-User Communication: Mediated 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): Indirect 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only	1. Entertainment = 4 2. Interest = 4 3. Customisation = 3 4. Interactivity = 2 5. Target Group = 5 **TOTAL =3.6/5.0**	6. Performance = 4 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 5 **TOTAL = 4.25/5.0**	10. Layout = 4 11. Graphics = 4 12. Visual Appeal = 4 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals =4 15. Quality of Information = 5 16. Quantity of Information = 4 17. Visual Information = 4 18. Credibility = 4 19. Evidence Base = N/A **TOTAL = 4.33/5.0**	**App Quality Score = 3.92/5.0**

Note: BCTs Behaviour Change Techniques, MARS Mobile Application Rating Scale

Table 8. Behaviour Change Techniques (BCTs), Gamification, and MARS (One App Example)



Note: Only the Behaviour Change Techniques (n=20) found within the apps were displayed in this graph.

Figure 2. Behaviour Change Technique Prevalence in Apps

Gamification Techniques

Of the 29 apps we examined, less than half of the apps included gamification techniques (13/29 apps, 44.8%). When examining the 12 gamification techniques specifically, the most common characteristics for each technique are as follows: 1. Gamification Concept-to-User Communication: Direct (8/13 apps, 61.5%), 2. User Identity: Virtual Character (11/13 apps, 84.6%), 3. Rewards: Internal (11/13 apps, 84.6%), 4. Competition: No (9/13 apps, 69.2%), 5. Target Group: Healthy Individuals (13/13 apps, 100%), 6. Collaboration: No (10/13 apps, 76.9%), 7. Goal-Setting: Externally Set (11/13 apps, 84.6%), 8. Narrative: Episodical (12/13 apps, 92.3%), 9. Reinforcement: Positive (13/13 apps, 100%), 10. Persuasive Intent: Behaviour Change (13/13 apps, 100%), 11. Level of Integration: Inherent (13/13 apps, 100%), and 12. User Advancement: Presentation Only (8/13 apps, 61.5%). Further information on the rate of occurrence for each characteristic can be found for all apps in Tables 8 and 9 in the Appendices (an expanded version including all apps). A figure summarizing the first four gamification techniques' data can also be found below (Figure 3).

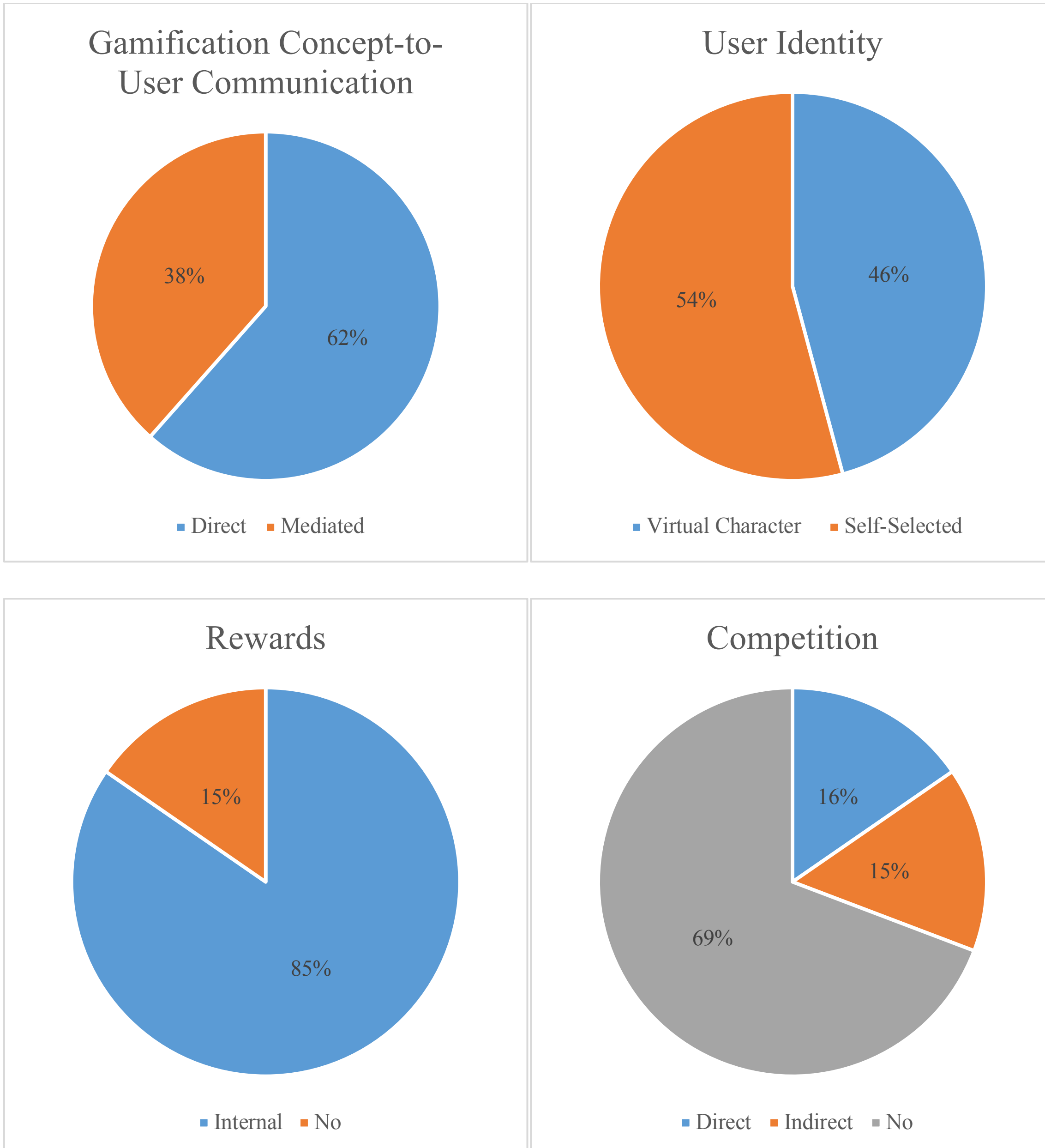


Figure 3. Pie Charts for Gamification Techniques

App Quality (MARS)

It is important to acknowledge that when using the MARS scale, it was applied with the interests of grades 4 and 5 students in mind, as they are the age focus of our study. Based on the scale, the average MARS score was 4.10 out of 5, with the lowest scoring app receiving a 2.93 (*KID-FIT Music*) and the highest scoring app receiving a 4.81 (*GoNoodle*). The four sections of the MARS scale received the following scores from highest to lowest, “Functionality” (Mean= 4.36), “Information” (Mean= 4.20), “Aesthetics” (Mean = 4.17), and “Engagement” (Mean = 3.78). It is also important to note that data scored as “N/A” was excluded from scores. Further information on the overall app ratings and the specific scores per section can be found in Tables 8 and 10 in the Appendices (an expanded version showing all apps). A figure summarizing this data can also be found below (Figure 4).

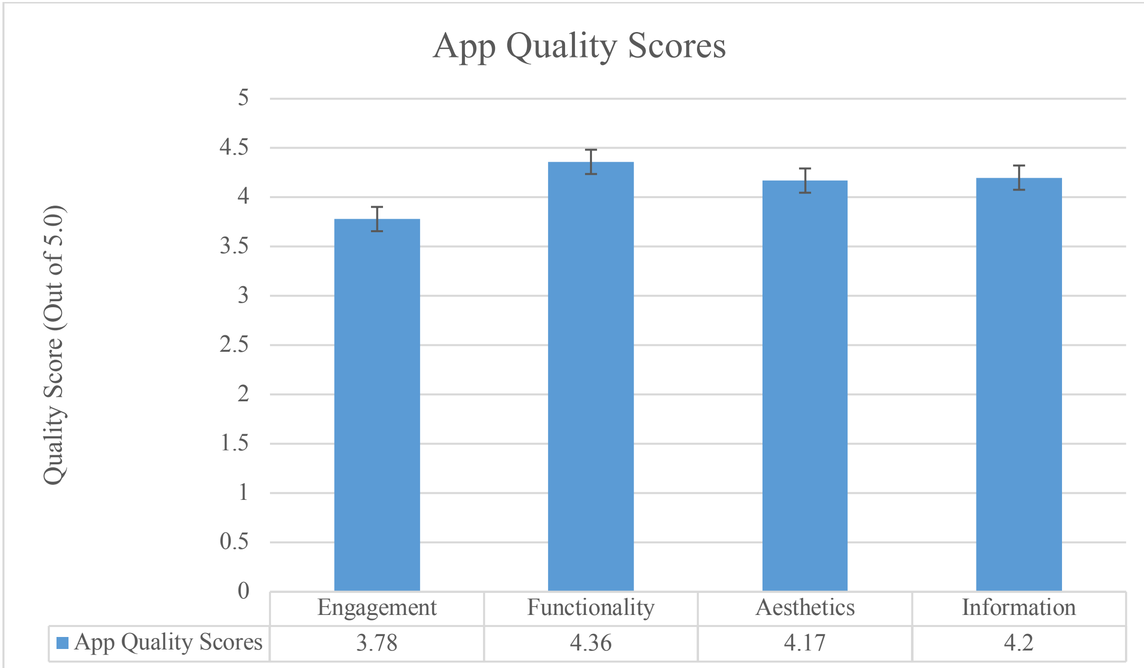


Figure 4. Average Quality Score Per Section

Relationship Between Behaviour Change Techniques, Gamification Techniques, and App Quality

When further investigating correlations between app quality and the inclusion of behaviour change or gamification techniques, the findings were as follows: apps that included gamification techniques on average utilized eight behaviour change techniques and had an overall quality rating of 4.17/5.0. In comparison, apps that did not include gamification techniques on average utilized five behaviour change techniques and had an overall quality rating of 4.04, both of which are less than apps that included gamification techniques. These findings can be found summarized in Table 11 below and in the Appendices (an expanded version including all apps). This could perhaps suggest that the use of gamification techniques and an increased implementation of behaviour change techniques increases the overall perceived quality of apps.

	Gamified Apps (13/29, 44.8%)	Non-Gamified Apps (16/29, 55.2%)
Behaviour Change Techniques	8	5
Overall App Quality Score	4.17/5.0	4.04/5.0

Table 11. Gamified Vs. Non-Gamified Apps

Further calculations show that paid apps received overall ratings by users that were higher on average than those of free apps (4.5/5.0 paid apps; 4.29/5.0 free apps). However, a limited number of paid apps received a user rating (2/7 apps, 28.6%), while a more sizable amount of free apps received a user rating (15/22 apps, 68.2%). In contrast, the overall app quality, number of behaviour change techniques utilized, and the use of gamification techniques was greater in free apps than paid app, which can be seen in Table 12 below.

	Rating on Store	Behaviour Change Techniques	Gamification Techniques	Overall App Quality Score (MARS)
Paid Apps	2/7 apps included ratings, 28.6% = **4.5/5.0** **SD** = 0.14	7/7 apps included BCT's, 100% = **4**	1/17 apps, **14.3%**	7/7 apps included quality scores, 100% = **4.02/5.0** **SD** = 0.35
Free Apps	15/22 apps included ratings, 68.2% = **4.29/5.0** **SD** = 0.51	22/22 apps included BCTs, 100% = **7**	12/22 apps, **54.5%**	22/22 apps included quality scores, 100% = **4.12/5.0** **SD** = 0.47
Note: BCTS Behaviour Change Techniques, MARS Mobile Application Rating Scale				

Table 12. Descriptive Characteristics Between App Quality, Behaviour Change, and Gamification Techniques

Lastly, when examining app quality, gamification and behaviour change technique present amongst both stores it was concluded that apps on the Apple Store had a higher presence of gamification techniques than those on the Google Play Store (45% of 20 apps vs. 44.4% of 9 apps), but apps on the Google Play Store had a greater number of behaviour change techniques embedded within apps (8 vs. 5), as well as a higher overall perceived quality (4.26/5.0 vs. 4.02/5.0). These findings suggest that apps on The Google Play Store may have a greater ability to produce the desired goal of the app and have a positive effect on health and physical activity levels. A summary of the findings can be seen above in Table 12.

3.4 Discussion

Primary Results

In our study, we searched the app market to discover what apps were available on the Apple and Google Play Store that were physical activity based. Our ultimate goal was to better understand the characteristics of apps, specific to children, with the ability to be used for Daily Physical Activity (DPA) in schools. In doing so, we examined the presence of behaviour change and gamification techniques, as well as quantified the quality of these apps based on the MARS scale. When using the MARS scale, the engagement, functionality, aesthetics, and information quality of apps were examined.

In our study, there was an average of six behaviour change techniques with the most commonly embedded techniques being *Habit Formation, Instruction on How to Perform A Behaviour*, *Goal Setting*, *Demonstration of the Behaviour*, *Prompts/Cues*, and *Adding Objects to the Environment*. The least commonly embedded techniques were *Monitoring of Behaviour By Others Without Feedback*, *Biofeedback*, *Credible Source*, *Material Incentive (Behaviour)*, *Material Reward (Behaviour)*, and *Social Reward*. These results were consistent with previous studies examining the presence of behaviour change techniques in physical activity based apps. Specifically, previous studies reported four, six, and eight techniques on average embedded within apps, consistent with our findings (Direito et al., 2014; Conroy, Yang, & Maher, 2014; Yang, Maher, & Conroy, 2015). Similarly these studies also found *Instructions on How to Perform A Behaviour*, *Demonstration of the Behaviour*, and *Goal Setting* to be the most commonly utilized techniques, with the addition of *Self-Monitoring of Behaviour* being another commonly utilized technique (Direito et al., 2014; Conroy et al., 2014). These studies also found that *Monitoring of Behaviour by Others Without Feedback* and *Material Reward (Behaviour)* were least frequently embedded within physical activity based apps (Yang et al., 2015). These findings suggest that it may be important to consider adding demonstrations in verbal, written, and picture/video form, as well as self or externally setting goals to promote physical activity. Further, these findings suggest that monitoring of behaviour by others through the app without feedback does not increase physical activity levels and is not a necessary technique to be included in apps.

In this study less than half (44.8%) of apps included gamification techniques. In the literature it has been found that only 4% (64/1680 apps) of health apps included gamification techniques (Edwards et al., 2016). Another study found that 45.2% (118/261) health apps included gamification techniques (Lister, West, Cannon, Sax, & Brodegard, 2014). The Edwards et al. (2016) study examined medical, health and wellness, and fitness apps on both the Apple and Google Play Store, while the Lister et al., (2014) study examined just fitness and health apps (specific to diet and physical activity) on only the Apple Store (Edwards et al., 2016; Lister et al., 2014). It was not specified whether any other the apps examined were specific towards children. These studies all suggested that further research is required to understand the benefits of gamification techniques on health based apps in specific, a current gap in the literature (Bardus, van Beurden, Smith, & Abraham, 2016; Edwards et al., 2016; Lister et al., 2014).

On average, the overall app quality was 4.10 which can be considered as "good". Other studies in the literature using the same methods have similar ratings around 3.1 and 3.6 which can be considered as adequate/moderate (Bardus et al., 2016; Schoeppe et al., 2017). As these ratings could be considered as subjective and included different apps, this could explain the differing of quality score. Similarly, in these studies the sections quality scores were as follows, from greatest to least, functionality, aesthetics, engagement, and information (Bardus et al., 2016; Schoeppe et al., 2017). In this study the scores were different with functionality also having the greatest score, but then followed by information, aesthetic, and then engagement. The differences in these results could be caused by subjective measures. This data does suggest that users enjoy apps that are easy to use, and that are reliable in terms of performance. Furthermore, results indicate users feel as though apps require greater customization and creativity to ensure repetitive use. As no apps included in this study included evidence based content, this is a gap in the literature that should be addressed. Developers should include evidence-based content in apps to ensure overall success in apps reaching their intended goal, as well as potentially increasing the overall quality of apps. It may also be useful modify existing app evaluation tools to include rating/subscales for existence of evidenced-based content.

Based on our findings and those in the literature, when designing an app it is important to consider incorporating behaviour change and gamification techniques, as well as engagement, functionality, aesthetics, and information quality of the app. Our findings have shown that apps that include both behaviour change and gamification techniques are perceived to have a greater quality score. Furthermore, apps should be easy to use and be reliable in terms of performance (Bardus et al., 2016). In order to ensure repeat use, app users should have a variety of customizable and interactive features. Apps should incorporate demonstrations of the wanted behaviours through video/picture, audio, and written instructions, and should set clear goals to insure success. Based on our findings, apps should also include virtual characters, externally set goals, intent to change behaviours, utilize positive reinforcement, and include a rewards system to elicit success. Future studies should examine the effects of gamification techniques on health apps, and consider the target age and environment of app, as most within our study were not geared for the adolescent population and the indoor environment, or were geared for too young of children.

Strengths and Limitations

This studied reviewed the app market to discover what apps were available for children to use to increase physical activity levels, while also considering the indoor environment of the classroom. We examined the behaviour change and gamification techniques present, as well as the overall quality of 29 apps using the MARS scale. Our study was able to find a relationship between the inclusion of behaviour change and gamification techniques and overall higher app quality scores, which has not been examined previously in the literature. We were also able to establish that gamification had a positive effect on apps overall quality, while previously there was little to no knowledge on the effects of gamification techniques on apps. However, there were limitations to our study. As we excluded apps that were of a price higher than $9.99 and did not pay for in-app purchases, we could have excluded potential apps that would have a positive effect on our target population (children). We also excluded apps that included any form fitness challenges, push-ups, or trackers as we felt they were geared towards more of an adult population and could not be used indoors successfully. By doing this we could have potentially excluded apps that would have been relevant to our study. We also used the MARS scale for app rating which is a quantifiable tool, but could be seen as being subjective (as the researcher had to evaluate scale items from the perspective of a young child), and only had one researcher analyzing the data. With multiple researchers we could have allowed for less subjective results. It may also be useful to have end-users (children) rate the apps themselves to establish convergent validity of the MARS tool.

We also acknowledge that the evaluation of apps was over a short period of time with apps not including repeat use where updates on content could have been conducted, potentially changing the outcomes of our results.

Once apps were downloaded researchers discovered only some apps were actually geared for children (i.e., that would be enjoyable and stimulate repeat use). Also, most apps could not be used inside of a school and require an outdoor environment. Future app development should aim to target the child population and be designed specifically for apps that could be used in schools and classrooms, as this is a current gap in the app market.

Conclusion

The app market contains many apps for physical activity promotion, but very few are specifically designed for children and could be used for DPA in the classroom. Of the apps examined, on average they contained six behaviour change techniques and were of an overall better perceived quality when associated with an increase in behaviour change techniques and the presence of gamification techniques. The behaviour change techniques most commonly utilized in apps were *Habit Formation* and *Instructions on How to Perform A Behaviour*, suggesting these techniques have the greatest ability in producing a desired goal. Apps tend to have a high functionality score, suggesting users enjoy apps that are easy to use. Apps scored lowest in terms of engagement, suggesting there is a need for a greater ability to customize apps that can attract repeat use.

Researchers should continue to examine the child population to ensure an app can be properly tailored to their needs, as well as gain a better understanding of the classroom to develop an app that would be better equipped to the indoor environment of classrooms, while still incorporating the most beneficial behaviour change techniques for increasing physical activity.

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Chapter 4.

Focus Group Interviews With Teachers to Discuss the Perceived Constraints of DPA Implementation Within the Classroom

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4.1 Introduction

Physical inactivity has become a concerning pandemic worldwide. In fact, using device-measured data, it has been found that Canadian youth spend on average 8.6 hours per day, or 62% of their waking hours in sedentary activities, with only 9% of boys and 4% of girls accumulating 60 minutes of moderate-to-vigorous physical activity (MVPA) per day, at least six days a week (Colley et al., 2011). Physical activity is critically important for health (Maher et al., 2013). It is defined as any activity that engages skeletal muscles and raises energy expenditure above the resting level (Caspersen, Powell, & Christenson, 1985). It has been shown across many studies to increase quality of life, decrease the rate of morbidity and mortality, and decrease the risk of developing diabetes and cardiovascular disease (Maher et al., 2013; Melzer, Kayser, & Pichard, 2004; Warburton, Nichol, & Brendin, 2012), among children. Physical activity is also beneficial for academic performance. It has been shown to aid children in developing proper motor skills and self-efficacy, as well as increased concentration and focus, oftentimes increasing academic success in school (Warburton et al., 2006; Sigman, 2012). Thus, school may be an important place to have children engage in physical activity.

Daily Physical Activity (DPA) is a program that was implemented into elementary school curriculum as an additional opportunity for MVPA at school (Stone, Faulkner, Zeglen-Hunt, & Bonne, 2012). It was implemented into Ontario schools with the intent of increasing current physical activity levels of children in the classroom throughout the day, as children spend a large majority of time at school in sedentary activities (Stone et al., 2012). It consists of 20 minutes of MVPA, where the goal is to increase one's heart rate above resting level (Stone et al., 2012). DPA is not restricted or limited to a specific type of activity, therefore it is open-ended in terms of possibilities.

Currently, DPA is not being implemented in the school system as intended. In a study of students (boys n= 478 and girl n=549) in the Toronto District School Board (schools n=16), device measured data indicated that only 49% of students participated in DPA every day of the school week, with 16.6% participating in DPA two days per week, 17.9% participating in DPA three days per week, and 16.1% participating in DPA four days per week (Stone et al, 2012). It was found that students who participated in DPA every day had higher levels of physical activity, achieved a greater overall intensity level of physical activity, and accumulated significantly more minutes of MVPA across the school week, showing the positive effects DPA has on physical activity behaviour if properly implemented (Stone et al., 2012).

It is important to understand the reasoning behind the lack of improper implementation. Research indicates that there are many barriers to DPA implementation in the classroom. The three main barriers are as follows: lack of space, lack of time, and lack of resources. Teachers often express not having enough space to conduct DPA in the classroom, emphasizing the concern for safety and disinterest in having to move furniture around in order to have enough space to ensure safety (Strampel et al., 2014). Further, teachers added that curriculum expectations and the demands from other classes often prevented teachers from engaging in DPA at the expected rate (Brown & Elliot, 2015; Strampel et al., 2014). Lastly, teachers felt they were not provided with the adequate resources to confidently run a DPA session, often stating they were supplied with little to no equipment (Allison et al., 2016; Strampel et al., 2014). These three barriers are the main cause behind a lack of DPA implementation in the classroom.

Additionally, one must understand the current gaps surrounding DPA and its implementation in the classroom. One area with little research is the use of technology to aid in the proper implementation of DPA in the classroom. It has been become evident through semi-structured interviews with teachers that technology, such as computers and smart boards can be a facilitator to assist in successful DPA implementation (Brown & Elliot, 2015). However, no studies have examined to use of apps specifically within the classroom, or the features of technology that teachers would require for both themselves and students to use an app within the classroom.

Another area that has not been researched that could largely impact the implementation of DPA in the classroom is the different grades themselves. Different grades and age ranges present different challenges. Years that include standardized testing (three and six) present with greater curriculum expectations of those of other grades (Gardener, 2017). Children in higher grades are larger in size (as they are older), which further adds to a constraint of space. Thus, we aimed to specifically investigate if teachers of grades 4 and 5 also experienced the constraints of time and space.

These barriers highlighted above need to be addressed in order to assist in the proper implementation of DPA in the classroom. As technology is evolving and becoming more popular amongst the youth, with approximately 46% of children aged nine to 16 having access to technology or a device of their own, it is a viable opportunity for an intervention (Mascheroni & Ólafsson, 2016). Additionally, it has been previously stated by teachers that technology, such as computers and smartboards, are a facilitator to

DPA implementation, perhaps suggesting that an app could have the same impact. Currently there are a variety of physical activity based apps available in the app market, but very few are specific to children, and further, there are minimal currently available that could be usable within the constraints of the classroom (Schoeppe et al., 2017). However, the apps that are physical activity based have shown promise in increasing physical activity levels (Schoeppe et al., 2017). These findings suggest an app would be a viable intervention tool, but as of now few apps are specifically designed for DPA. However, little research is available on the perspectives of teachers on using such apps to support delivery of DPA in their classroom.

Research is needed to understand the current resources teachers have available specifically for DPA and the appetite for using technology in the classroom specifically for DPA, as it has been previously mentioned in the literature that it is a possible facilitator to proper DPA implementation. At this time, little is known of whether teachers would use an app to aid with the implementation of DPA, as most findings were specific to computers and smart boards, but it a viable option due to the increasing access to technology that children experience. For this reason, focus group interviews with teachers were conducted to discuss the viability of using an e-resource (app) for DPA, as well as to gain a better understanding of the level of DPA that is achieved in the classroom, and to further understand the identified barriers regarding the improper implementation of DPA.

Theoretical Framework

Methodological Orientation and Theory. In order to conduct a proper focus group interview, we situated ourselves within one of the five theoretical frameworks of

Qualitative Research. Theoretical Frameworks are applied to gain a better understanding of the material in a specific situation by using a variety of theories or models (Malterud, 2001). As our research was unique and did not fit within one specific framework, we used techniques from the Phenomenological Framework (Phenomenology) and from the Interpretive Description. The Interpretive Description is not one of the five Theoretical Frameworks, but rather, is a new methodology that has been developed. In Phenomenology, the focus is on an individual's perspective to a specific experience (Connelly, 2010). It can be classified as examining the nature of experience, by examining the point of view of the individual experiencing the phenomenon (Connelly, 2010). This can be achieved by examining the quality of the experience through stories, interviews, and observations of an individual who has experienced the phenomenon of interest (Connelly, 2010).

As we were examining the experience teachers had with DPA and its implementation, we used techniques from Phenomenology, such as using focus group interviews to better understand this experience. As we were not necessarily examining a phenomenon in particular, for example, we were not examining how well teachers implement DPA into the classroom, but rather examined the perspectives of teachers pertaining to many different factors, such as how often they implemented DPA into the classroom, it was more accurate to say we used certain techniques from Phenomenology. Therefore, we state that we used techniques from this framework, but were not situated within it.

In addition, we used techniques from the Interpretive Description (ID) methodology. This technique was developed to generate knowledge in applied health disciplines in order to create clinical context on a topic (Thorne, 2016). Similar to Phenomenology, ID looks to examine a phenomenon, but in a clinical setting. In this case, it looks to examine the themes and patterns amongst the perspectives of participants, while still accounting for variation (Thorne, 2016). Often in order to examine these perspectives, researchers using the ID methodology will conduct focus group interviews. As we were intending to generate knowledge on DPA, which was related to the health levels of children, we were situated within the applied health field, one that is focused on in the ID. We were examining the themes, as well as teacher perspectives that occurred amongst responses in relation to DPA occurrence and implementation. We used these two frameworks and methodologies to guide our qualitative focus group study.

Purpose

The purpose of the focus group interviews was to develop a better understanding of the constraints teachers face with integrating DPA into the classroom, as well as understand teachers' appetite for a technological solution. This perspective is important for informing the design and development of a DPA based mobile application that can be used as a resource in the classroom. We used the COREQ checklist to organize our data for the following methods section (Tong, Sainsbury, & Craig, 2007).

4.2 Methodology

Eligibility Criteria

Participants. Participants were adults who taught Grades 4 or 5 at a time in their teaching career following the implementation of DPA, as a homeroom teacher. All teachers were recruited from the public school system and worked in Ontario.

Recruitment. Participants were primarily recruited through email messages. Emails were sent to a school board representative via a research team member that was in charge of organizing testing through our affiliate school boards. For proximity and ease, we conducted the focus group interviews with participants at various schools within the Durham Catholic District School Board (DCDSB). This recruitment was conducted using purposive sampling, in which we selected participants who were in the field of education that also had an understanding of DPA and technology. This also allowed us to recruit the necessary sample size to allow for data saturation (i.e., "the point at which no new information or themes are observed in the data") (Guest, Bunce, & Johnson, 2016, pg. 59).

Once contact information of potential participants was received, they were emailed with a letter of information and consent form to familiarize themselves with the study. This process was done to ensure participants had an understanding of the project and the focus group interview before they began, and allowed for the participants to brainstorm any questions they may have had. We also supplied a hard copy of these documents for participants to review at the beginning of the focus group, where any questions or concerns could be addressed in-person.

Sample Size

Data Saturation (Number of Focus Groups). The average number of focus groups required to ensure data saturation is estimated to be five to nine (Carlsen, & Glenton, 2011), while some suggest that the general 'rule of thumb' for the suggested number of focus group interviews is three to five. Generally, two or fewer would not provide true representation of the sample, while three to five "avoids rigorous questions regarding the who, what, and why" (Cleary, Horsfall, & Hayter, 2014, pg. 474).

Data Saturation (Number of Participants). In terms of the number of participants per focus group, research suggests that the ideal number of participants for focus group interviews to reach data saturation is approximately five to eight (Ness, 2015). It was stated in a systematic review that many studies did not suggest a minimum or maximum number of participants, or how many participants were included in their study, perhaps highlighting a gap in the literature (Carlsen, & Glenton, 2011). Based on our research, our goal was to recruit ten participants to ensure sufficient depth in responses.

Therefore, we conducted four focus group interviews with a total of ten participants (n=2-3 participants per focus group).

Setting

Setting of Data Collection. In order to conduct these Focus Group Interviews, ethical approval was obtained by the Ontario Tech University Research Ethics Board/Animal Care Committee under **REB Certificate #14426**. The data collected from the focus group interviews occurred where the teachers/participants work, in one of their classrooms. More specifically, the interview was scheduled at a date, time, and location that was most convenient to the participants. When participants could not meet in their classroom to conduct the focus group, the focus group was conducted at a local coffee shop.

Presence of Non-Participants. Other than the participants in the study, there was only one researcher (moderator) in the room during the focus group sessions. This moderator was the individual who conducted the focus group, i.e., explained the procedure and the consent form, ensured the participants understood the content and process of the focus group, and asked the participants the questions from the interview guide.

Data Collection

Interview Guide. The interview was semi-structured in nature, and thus included specific question but provided the flexibility for the moderator to take different directions, as needed. The interview guide can be found in the Appendices (Appendix B8). For the interview guide, the first two questions targeted app use, for example what apps teachers were currently using, as well as what features of an app would be most useful to teachers. Questions three to five were designed to understand the context of the teachers in this specific school board, as resources and culture vary significantly across locations.

The guide consisted of five questions, as outlined below:

1. What is your perspective and level of experience on mobile applications in the classroom to facilitate learning?
2. If you were to use a physical activity based mobile application in your classroom for daily physical activity (DPA) what main features would be most useful to yourself?
3. What main barriers, if any, prevent you for conducting DPA sessions every day?
4. What activities, exercises, or games do you use when you run a typical DPA session?
5. Are you provided with the proper resources to conduct DPA sessions and do you feel confident in conducting them? If so, what do these resources contain?

Audio Recording. Audio recording of the focus group interviews was done strictly for data collection purposes in order to directly quote participants. Audio recording was only used if consent was granted by the participants. For the case of these focus group interviews, consent was granted by all participants.

Duration. The duration of the focus groups fluctuated depending on the number of participants. On average, the focus group interviews lasted 30-45 minutes in duration. The duration of the focus groups was also dependent on the depth of response we received for each question. The researcher used the following outline for time purposes: explanation of the project (letter of information) and consent form signing, as well as the recording testing completed within the first 10 minutes of the interview, interview with questions 20-30 minutes in length, and the last five minutes as a period to quickly debrief after the interview, discussing the experience, and thanking the participants.

In order to ensure the researcher stayed within the time frames allotted, the researcher ensured there was a clock nearby. They checked the time as frequently as possible without disturbing the interview. This allowed for the interview to stay on schedule and prevented it from becoming too long in duration.

Data Analysis

The data in this focus group interview was transcribed word for word in order to ensure the integrity of the interview was maintained. The transcribed documents were thoroughly read multiple times with the researcher focusing on identifying key words, ideas, or concepts that arose multiple times throughout the interview. These "themes" were further divided into "subthemes", where appropriate. A formal coding framework was created in which the researcher coded moments in text where important themes and sub-themes occurred. The researcher was then able to sort each piece of coded information into a category in the coding framework, which was later important when analyzing data.

4.3 Results

Sample Characteristics

Four focus group interviews were conducted (n=10). All teachers taught within the Durham Region under the Ontario Curriculum. These teachers taught within the range of grades one through eight, but had all taught either grades four or five at some point in their teaching career. It became evident that data saturation was reached during these interviews as participants stated the same, or very similar answers to the questions being asked. In other words, no new data or themes were emerging amongst the last one or two interviews.

Three main themes emerged from the data collected: **constraints to DPA implementation**; desired **app features**; and **resource availability**. A detailed flow chart of the themes and sub-themes can be found in the figure below (Figure 5).

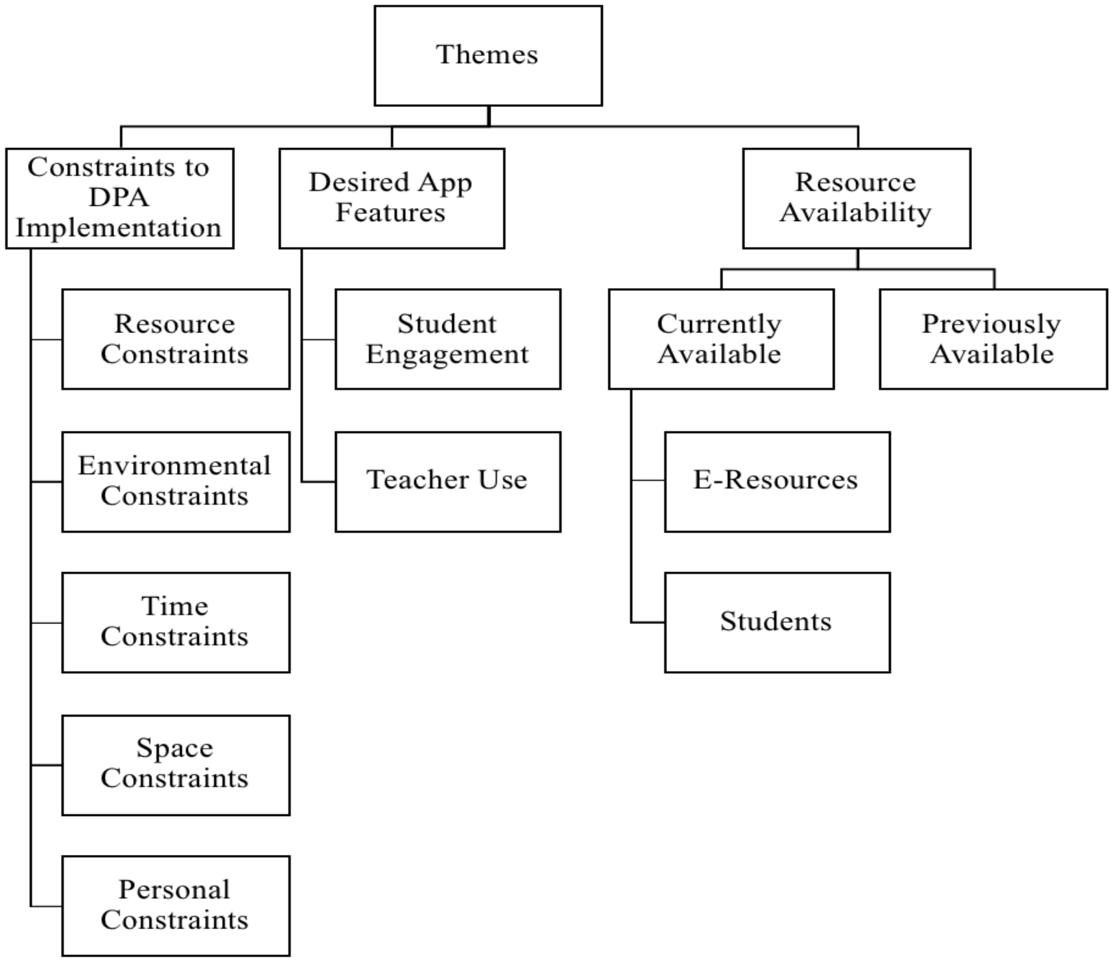

Figure 5. Themes and Sub-Themes from Focus Group Interviews

Theme 1 - Constraints to DPA Implementation

This theme had several sub-themes, namely: ***resource constraints***; ***environmental constraints***; ***time constraints***; ***space constraints***; and ***personal constraints***.

Sub- Theme #1 - Resource Constraints. Teachers often mentioned they had difficulty "coming up with ideas" on their own due to a lack of resource support provided to them by the school board. As stated by one teacher, "I do not at all feel that we have resources", and further by another teacher, "I don't ever recall ever being given a resource about DPA". Teachers also emphasized they had to go out of their way to find online resources, and that they did not like having resources in multiple files/locations. Their preferences was to have resources "in one place".

Sub-Theme #2 - Environmental Constraints. Teachers stated that they could only implement DPA if it was outdoors. However, conducting DPA outdoors is associated with constraints such as weather. Living in Canada where winters can be long and unpredictable, having DPA outside was often found to be nearly "impossible". Teachers often mentioned that the conditions associated with weather were not ideal, stating, "you know, it's not always the greatest weather", impacting their ability to go outside for DPA.

Sub-Theme #3 - Time Constraints. Teachers emphasized that there was not enough time in the school hours to implement DPA into the classroom. Some of the time constraints mentioned were having an allotted time of 30 minutes per period, being a rotary teacher in which they are moving from classroom to classroom throughout the day, teaching a year that involves standardized testing in which focus is heavily on the subjects of math and language, or difficult curriculum expectations that require a focus to be on other subjects. Teachers who were teaching grade three and six, or standardized testing years were often told by employers to “discard your science, social studies, and DPA and put in math and language”, adding that, “the pressure of covering language and math is really extreme”. When discussing curriculum expectations teachers stated that it’s “a daunting curriculum, you know you’ve got so much to cover”. In general, teachers often found there was not enough time and discussed it being “hard to get a 20 minute block” to allot to DPA.

Sub-Theme #4 - Space Constraints. Teachers often mentioned the classroom not being suitable for DPA due to a lack of overall space. They further explained that teaching in a portable provided less space than a classroom, which hindered DPA implementation to a greater degree. Teachers often stated that the “desks were in the way” and they “don’t want to have to move the desks around every time I do DPA”. Further, it was also commonly mentioned that lack of space in the classroom could lead to student injury “because you’re in the classroom and somebody’s going to get nailed and hit in the head”. Further with the junior grades of four and five it was commonly mentioned that “there’s just so many bodies, and desks, and tables in the classroom with older kids”.

Sub-Theme #5 - Personal Constraints. Teachers mentioned that they felt they were not taught how to properly instruct DPA. They emphasized having a lack knowledge on muscles and exercises, and therefore felt they were not able to effectively incorporate DPA into the classroom. For example, it was stated by one participant that their “knowledge of what is really appropriate you know for muscles and things like that is not there”.

Theme 2 - Desired App Features

This theme had two sub-themes: ***desired features for student engagement***; and ***desired features for teacher use***.

Sub-Theme #1 - Student Engagement. Teachers emphasized that it was important to include specific features of an app in order to ensure students would be engaged, and so it would be used as a resource for DPA. Teachers stated the app must be age appropriate and appeal to both genders otherwise "as they get a little bit older we sometimes will lose them with certain activities with DPA", which they further found hindered DPA implementation and success. Teachers also emphasized the app should have variety in terms of timers, categories in choice to increase engagement, stating they "don't want something that's gonna be 20 minutes every single time", and "there should be some sense of choice uh as well, students can choose that".

Teachers often mentioned that it became difficult to calm students down following DPA, which can impede school work production, stating "something I've noticed with some of the activities that I've done with the kids it's heightened them so much that it's been difficult to bring them back down again", further adding they would prefer something to "not create a whole lot of chaos".

Other examples of features teachers emphasized were important to student engagement are as follows: excludes all equipment that could be required for activities, has a cooldown option to bring energy levels down after exercise, the ability to increase students' energy and heart rate in order to achieve health benefits, utilizes body breaks as they are beneficial to student success in the classroom, and "highly engaging" to students in order to achieve success.

Sub-Theme #2 - Teacher Use. Teachers identified what features they desired to be incorporated into an app in order for implementation success and increased user engagement. Teachers suggested that an app should incorporate a sense of collaboration, as identified by one teacher "collaboration, some sense of working as a team with the students." It was also mentioned, by multiple teachers that it would increase likelihood of them using a DPA based app if it was linked to curriculum. One teacher stated that "the idea of connecting it to something that we have to teach already for DPA would be really beneficial". Furthermore, teachers emphasized that the app must "constantly be current, so if you're using music that is three years old to them that's ancient", in which case, interest would be lost. Also, teachers identified that the app must be easily left for a supply teacher, stating "I would want apps that… (coughs) are user friendly so I could leave them for supply teachers". Lastly, teachers emphasized the app must require little effort and time to set up. They did not want to have to "set up ahead of time" and wanted apps to be "low organization" with "little navigation" so they were "easy to use and access".

Theme 3 - Resource Availability

This theme had two sub-themes in which it could be further classified, which are as follows: ***currently available***; and ***previously available***. The sub-theme of ***currently available*** could further be categorized into two further sub-sub-themes of ***e-resources***, and ***students***.

Sub-Theme #1 - Currently Available. The sub-theme of ***currently available*** was further be categorized into two sub-sub-themes of ***e-resources***, and ***students***.

E-Resources. Teachers outlined that few e-resources were available for them to use during DPA, none of which were provided by the school. Of all of the resources, it appeared that the GoNoodle app was most commonly and consistently used amongst most of the teachers. Many teachers stated that GoNoodle was their "go to" program to use, one teacher even stated that it is their "best friend for DPA". Teachers stated they used the app GoNoodle most commonly out of all resources as it is "readily available and accessible" and since the "kids like the songs because they're goofy and silly". The app utilizes a variety of dance videos that students can sing and dance along to, requiring minimal set up and guidance from teachers, which they preferred.

Teachers also reported using another app called Headspace, stating they used it for "meditations, down time, calming, and focusing", to help bring students to a calmer state following DPA exercise at a higher intensity. They further stated that Headspace has a "children's section" and that it "offers more options" such as the "mindfulness" and "stretching exercises" options. Lastly, teachers also commented on using the website Ontario Physical and Health Education Association (OPHEA) for DPA type activities, although one teacher mentioned that OPHEA "is not DPA driven it's just suggestions".

Students. Teachers mentioned that they would often get inspiration for DPA from the students themselves, as well as their own children at home. Teachers stated they will ask the students, "give me your ideas. What's something you've enjoyed in the past?", so that they are "learning from them". Teachers also stated using activities they use "with [their] own children" as resources for DPA.

Sub-Theme #2 - Previously Available. Teachers stated that there were beneficial resources available in the past that they no longer have access to. The resources the teachers mentioned were DPA cards that provided specific activities, and having Professional Development (PD) Day workshops and lessons available at the board office. Teachers commented that around 10 years ago when DPA was first implemented there was a greater focus and a more plentiful source of resources, stating “several years ago when DPA came out, there was a lot of umm attention given to it, and we were given a lot of resources”. They also stated that they were given resources such as exercise game cards and a DPA bin. Teachers added that “every classroom had a bag of DPA equipment and our Phys. Ed teacher in that school put together a duo tang for every single teacher in the school of simple DPA activities”, therefore DPA “happened every single day without fail because “it was easy””. The DPA bags/bin contained “skipping ropes, bean bags, little nerf spongy balls”, and a “soccer and basketball”, but unfortunately over the years the bins had “stuff out of them disappear, so all of a sudden your DPA bin is no longer” and unfortunately they were not replenished. Similarly, the exercise game cards were no longer circulated. Teachers also used to be given the opportunity to go down to the “board office” or have a board member come to their school on PD Days for DPA activity workshops. This no longer occurs; teachers stated they “don’t feel we’re provided with adequate PD” specific to DPA, as there are no longer workshops on “how to perform daily physical activities in your classroom effectively”.

4.4 Discussion

The purpose of this study was to identify constraints that inhibit the proper implementation of DPA, as well as the needs of teachers to support implementation of DPA in the classroom, and the appetite for using technology to deliver DPA. The primary finding was that teachers felt that time and space were significant constraints to proper

DPA implementation, even in grades 4 and 5. A secondary finding was that teachers felt as though they were not supplied with adequate resources to confidently deliver DPA, and that a mobile application could meet these needs. Based on these findings, it is evident that there is a need for appropriate resources to support teachers in the classroom, and resources that overcome constraints pertaining to time and space.

Teachers clearly indicated that there was not enough time in their schedules to implement DPA. The lack of time was primarily a result of curriculum expectations, especially in years where students were expected to complete standardized testing. This finding is consistent with the current literature. In a study conducted by Allison et al. (2016), it was found that 78.8% (n=230) of teachers agreed or strongly agreed that a lack of time in general was a barrier to successful DPA implementation in the classroom (Allison et al., 2016). Similarly, Strampel et al. (2014) found that standardized testing strongly impacted DPA implementation, with 49.6% (n=68) agreeing, and 30.7% (n =42) strongly agreeing that Education Quality and Accountability Office (EQAO, an independent government body that oversees reading, writing, and mathematics tests in Ontario for students in Grades three, six, nine, and 10: OCASI, 2016) puts pressure to focus on math and language at the expense of DPA (mean = 4.05, SD = 0.83) (Strampel et al., 2014). Lastly, in a study conducted by Brown & Elliot, 2015, curricular demands and limited time for DPA (n=17) were common barriers to implementation. Participants considered DPA to be a lower priority compared to other subjects, as it is not a testable subject, and there are no consequences to not implementing it into their schedules (Brown & Elliot, 2015). Collectively, these findings and the results from the current study suggest that time is perhaps the most impactful constraint related to DPA. For this reason, DPA resources developed should require minimal supervision on part of the teacher to ensure they are given time to prepare for other classes or to do marking.

Teachers also felt there was not enough space within the classroom to properly conduct DPA, impacting the frequency of DPA implementation. This too is consistent with previous research which indicates that space is cited as the greatest barrier to DPA implementation (Allison et al., 2016) and the size of classroom in particular is a barrier for indoor DPA (Strampel et al., 2014). A study by Brown & Elliot, 2015, found a different space constraint that teachers had to negotiate pertained to injury. In particular, participants (n=11) felt DPA activities posed the threat of injury due to inadequate room for students to properly perform the activities (Brown & Elliot, 2015). Clearly, space is a significant constraint, thus resources developed for DPA must be feasible in the space available within the classroom and must consider the safety of the students.

It should also be noted that teachers felt they were not supplied with adequate resources to conduct DPA sessions, impacting their confidence levels and causing teachers to neglect DPA implementation (Brown & Elliot, 2015). Also, in many instances throughout the interviews teachers mentioned the possibility of using an app in the classroom if it were to include specific features that would ensure it is both easily useable to teachers, and engaging to students. Currently, there is a gap in the literature regarding what apps teachers are using specifically for DPA, and there are few apps specifically designed for DPA. Our research identified that the current app resources teachers are using for DPA are mainly GoNoodle and Headspace. Research has not been conducted to examine the effectiveness of these apps in increasing physical activity, nor has research been conducted to examine the quality of these apps. However, research has been conducted to examine the ability of behaviour change techniques to increase physical activity levels in a general setting, and therefore should be examined within the apps of GoNoodle and Headspace. A study by Dierito et al., (2014), found that most apps contained approximately 8.1 behaviour change techniques, utilizing most commonly, "provides instruction" (83% of 40 apps), "sets graded tasks" (70% of 40 apps), and "prompt self-monitoring" (60% of 40 apps) (Dierito et al., 2014). These were found to be the most effective techniques for increasing physical activity levels. There were significant improvements in the amount of physical activity accumulated per day in comparison to apps that do not include behaviour change techniques (Dierito et al., 2014). Another study by Schoeppe et al., (2017), further noted that these behaviour change techniques were most abundantly found in apps that were of a higher perceived quality, based on the Mobile App Rating Scale (MARS) (rho = 0.54, $p<0.001$) (Schoeppe et al., 2017). This suggests that behaviour change techniques are a potentially effective component of increasing physical activity levels, as it has been shown in the literature that apps that include these techniques have users who accumulate higher levels of physical activity, and are most commonly found in apps with a higher MARS score, therefore apps of a higher quality (Schoeppe et al., 2016).

We also found that teachers are interested in using technology to implement DPA, and that current mobile apps available have not been adequately evaluated. Based on the findings in this study, the possible solution to the lack of DPA implementation in the classroom would be a mobile application (app) that overcomes constraints pertaining to time and space. Currently, teachers resources are limited and are mainly comprised of e-resources. The resources they currently use are not entirely successful, as students often become easily bored which causes student engagement to decrease. These apps also require too much time and effort for teachers to set up. Therefore, a new app that incorporates the suggestions made by teachers could be a more successful resource for DPA, as it would address the needs both they and the students require. For this reason, when developing a mobile application, it is important to address all suggestions provided within these interviews.

Limitations

Our study included teachers of a variety of grade ranges, while still ensuring all participants had taught the grades we were targeting, that is, grades 4 and 5. This was a strength as we were able to identify constraints that impact teachers teaching grades where there is no standardized testing and where students are bigger. Nevertheless, teachers did bring up other years, as they had taught more than grade 4 and 5. A sample with participants that were strictly of our target population could have given us richer data for these grades, allowing for creation of an app that was better tailored for those specific grades. Another strength to our study was the design. Being able to have in-person interviews with multiple participants allowed for discussion that would not be possible if interviews were conducted over the phone or in writing. Lastly, due to difficulty with recruitment, we conducted four focus group interviews, just below the recommended number to ensure data saturation.

Conclusion

Based on our findings from this study, it is evident that teachers experience several constraints and lack adequate resources for appropriate implementation of DPA in the classroom. There is an appetite for an app that addresses the needs of teachers in overcoming these issues. As current resources are limited, an app that tailors the needs of teachers would be a feasible intervention strategy to increasing the success rate of DPA implementation in the classroom, further increasing health benefits to students.

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Chapter 5. Thesis Discussion

5.1 Summary

Based on the findings through a search of the current literature, as well as the two studies conducted in this thesis, it is evident that there are a lack of apps in the market available for teachers to use for DPA. The findings of our study suggest that a mobile app that can be used during DPA may be well received. Based on a search of the app market, there are no apps that are specific for DPA, and most apps were not specific to the child population. This was also consistent with previous studies in this field, with many noticing a low number in apps available that are specific to the child population (Schoeppe et al., 2017). Further, the apps currently available on the app market do not appear to consider the constraints of time and space, that teachers stated to be important factors in determining whether they deliver DPA.

As our study incorporated focus groups with the teachers, we were able to gain invaluable insight into the exact constraints teachers faced within the classroom, as well as their suggestions for the development of an app. The environmental scan allowed us to confirm that no such apps are available on the market. Thus, we endeavoured to create an app to fill this gap.

The app developed is called "Act-It-Out" and is similar to charades. There are eight categories students can choose from, those being: animals, sports, activities, jobs, fantasy, music, around the house, and mix. A picture of this can be found in the figures below (Figures 6, 7, and 8), as well as other design elements of the app. Upon clicking on the app icon, the user will see instructions on how to play the game. Students can then click the next button to move onto the next page of instructions, or the skip feature to move to the categories page. Students then choose one category or theme and can choose the level (easy, medium, hard, and cool-down). The easy section includes activities that would be classified as a low level of exertion, while these activities get progressively more intense with medium, and further more intense within the hard level. The cool-down section acts to engage students in activities that are of low exertion, preparing them for learning and lessons following app use.

Figure 6. Example of Menu Display for "Act-It-Out" App

Figure 7. Example of "Act-It-Out" App Instructions

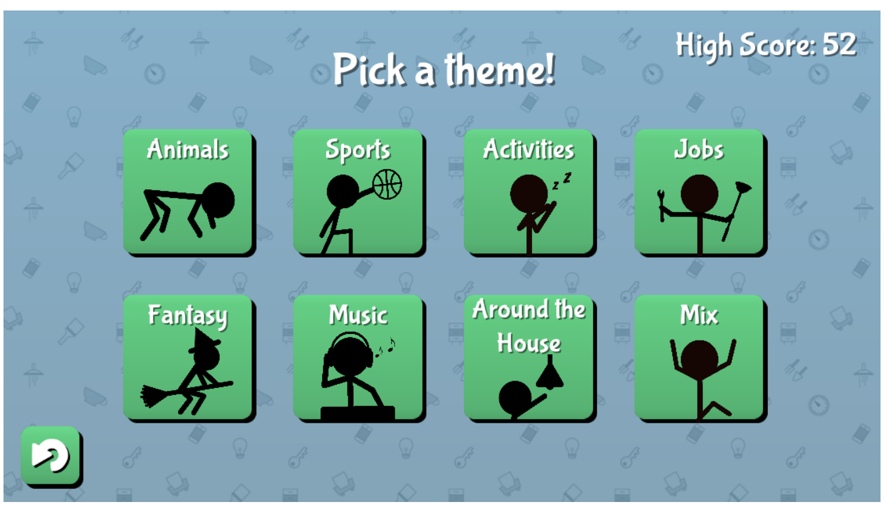

Figure 8. Example of List of Categories Within "Act-It-Out" App

In order to play, one student will hold the device while one to four other students stand around the device working together, or alone, to act out the word on the screen. The student holding the device has to guess the word/activity being acted out. If they guess correctly, the students acting out the word will have to tap the screen to move onto a new word. The student holding the device can tilt to device up or down to change the word if they are having difficulties guessing, a skip feature. This game lasts 60 seconds per round, therefore, rotating between five different students per tablet would take around five to seven minutes. This was done to ensure teachers had the flexibility to use the app for shorter time periods throughout the day, instead of 20 minutes per session.

This app does not require large spaces and can be performed inside without having to move desks. Therefore, this app is designed with the intent on conforming to the space constraints emphasized by teachers as well.

The words within the app are designed to entertain students in Grades four and five for repeat use. Further, the app provides students with a score. This is a rewards system that encourages students to beat their high score, adding a competitive element. The app utilizes a variety of colour to increase user engagement. The app was tested within a Grade five classroom. Students enjoyed the app and spent approximately 30 minutes continuously playing. Through observation, it was seen that students most enjoyed the aspect of competition between themselves and other students. Students suggesting adding more categories to choose from. As the app is not complete, these are suggestions that can be incorporated within the app. The app would also benefit from including picture or video, and written demonstrations of the actions, as that was a common behaviour change techniques embedded within physical activity based apps. A section for further resources available to teachers would also entice teachers to use this app as a resources. Further additions to the app that are required are increasing the quality of graphics, ensuring the app is gamified by perhaps adding a virtual character that can be designed, add more words to each category, as well as adding more categories in general, and expanding the app to cover all grades from one to eight.

The app that has been created is effective. Future research is needed to determine whether the app will be effective for longer-term use.

5.2 Future Considerations

When conducting studies similar in nature to this thesis, studies should aim to utilize multiple researchers when analyzing apps for behaviour change techniques, gamification techniques, and app quality ratings. This will ensure that the results are not subjective in nature. It would also be beneficial to include a greater sample size when conducting focus group interviews as this would provide a richer range of data. Researchers should further investigate the grades that involve standardized testing as different constraints may be placed on teachers, in which an app would be required to be developed with different goals and content. Researchers should also analyze gamification techniques to find their effect on increasing physical activity in health based apps, as well as identify which characteristics of these techniques are most common and effective amongst current apps in the literature (Lister, West, Cannon, Sax, & Brodegard, 2014; Edwards et al., 2016). It would also be beneficial to further research behaviour change techniques, as current research is often differing in terms of which techniques are most effective in promoting desired behaviour changes (Bardus, van Beurden, Smith, & Abraham, 2016; Direito et al., 2014). Lastly, future studies should conduct testing on apps with their intended target population to examine if apps are effective in achieving their intended goal, as well as ensuring apps are evidence informed as this is a current gap in the literature (Bardus et al., 2016).

Kirkpatrick Model

The Kirkpatrick Model is a way of analyzing and evaluating the results of programs (Rajeev, Madan, & Jayarajan, 2009). This model can be applied to evaluate the effectiveness of the app Act-It-Out in classrooms in increasing physical activity levels, and being a usable tool to both teachers and students. The application of this model would be achieved through pilot testing. This model consists of four levels: Reaction at Level One, Learning at Level Two, Impact/Behaviour at Level Three, and Results at Level Four (Rajeev et al., 2009).

In terms of reaction, this level aims to examine the program, in this case the app in the context of the classroom, specifically to identify how participants respond to the app (Rajeev et al., 2009). Further, following testing, reactions of participants could be measured, often with a questionnaire to understand the participants' reactions to the program, in this case the app (Rajeev et al., 2009). Initial testing was completed on the Act-It-Out app, but no data were collected. In this case, initial impressions observed were positive. Therefore, the reaction level of the model has been explored, however, a more structured pilot study grounded in the Kirkpatrick model would be beneficial.

In terms of learning, this level aims to identify how much the participants of the study learned from the app. Further, this stage aims to identify if the learning objectives were met (Rajeev et al., 2009). This stage is typically conducted with a test or examination (Rajeev et al., 2009). As the Act-It-Out app is not an educational tool specifically, and instead has to goal of increasing physical activity outcomes this level may not be relevant, nor applicable during app testing.

In terms of behaviour/impact, this level aims to assess performance changes following the program (Rajeev et al., 2009). In the case of app testing, the objective of this level would be to examine if children are becoming more active and increasing physical activity levels with the use of the app. This level can be examined in two ways, either formally with physical testing, or informally through observation and judgements (Rajeev et al., 2009). For the pilot testing of this app, both forms of testing would be beneficial.

Lastly, in terms of results, this levels aims to identify the benefits individuals have received from this program (Rajeev et al., 2009). In the case of Act-It-Out, this would apply both for students and teachers. For teachers, researchers could ask if teachers found the app easy to use, included features they would utilize, and ultimately, if they would use the app in their classroom for DPA. For students, accelerometers could be used to measure the level of physical activity students are achieving. A baseline would be required to compare the level of activity pre and post testing. It could then be concluded if the activity level in children is increasing and achieving an MVPA level. If the results indicate children are accumulating more minutes of physical activity at the MVPA level, this would indicate to the school boards that Act-It-Out is an effective tool for teachers to use in the classroom for DPA to assist children in meeting recommended guidelines.

Implementation

Implementation science examines the methods of implementing and promoting an evidence-based practice into real world contexts to improve the quality of health care, in this case, the success of DPA implementation (Eccles & Mittman, 2006). As an app has now been created, this establishes a foundation for implementation in a real world context, in this case, in classrooms. Following future pilot testing of Act-It-Out in classrooms using the Kirkpatrick Model to evaluate the app's impact, one would then begin to implement the app into classrooms. In order to properly implement an intervention such as an app in a real world setting, one must understand the science behind it (Eccles & Mittman, 2006). This app was designed based off of findings in the literature, as well as the environmental scan and the focus group interviews. This ensured the app was evidence informed.

The next step would be to find a partner who would assist in disseminating the app through their connection with Ontario school boards, such as the Ontario Physical and Health Education Association (OPHEA). With this partner, the following step would be to approach school boards across Ontario. Further testing could then be conducted in classrooms if teachers were interested, to ensure the app was meeting the needs of all areas across Ontario. As some areas may have less resources than others, modifications may be required to the app itself.

Following testing within school across Ontario, if successful, representatives from these school boards would be contacted regarding implementing this app within all schools across Ontario. The app would then be required to be uploaded onto the Apple and Google Play Store platforms where teachers could download it. Copyrighting and licensing of the app's properties would be required. Once the app was downloaded in all schools, a longitudinal study could be conducted to see the impact of the app in increasing physical activity levels over substantial amounts of time, as well as examining boredom levels of children with repeat use. This would conclude the implementation of the app in a real world context.

5.3 Conclusion

Based on a thorough search of the app market through an environmental scan and focus group interviews with teachers, it became evident that there is a gap in the research literature and the market on apps that are geared towards children that can be used during DPA, that also conform to the constraints teachers face within the classroom. As DPA is evidently not being implemented as intended and it's positive benefits have been documented, the need for an intervention resources to address this gap is required now. The evidence-informed "Act it Out" app we developed considers all the constraints teachers have; thus, it may allow for DPA to be properly implemented into the classroom, increasing physical activity levels and decreasing sedentary time amongst school-aged children. This can benefit the health of children and add ease within the classroom for teachers.

5.4 References

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Appendices

Appendix A. Tables

A1. Table 8. Behaviour Change Techniques (BCTs), Gamification, and MARS (One App Example)

App Name	BCTs Utilized	Total BCTs Utilized	Gamification Included?	Gamification Techniques	MARS Section A (Engagement)	MARS Section B (Functionality)	MARS Section C (Aesthetics)	MARS Section D (Information)	MARS Total Score
5-2-1-0 Kids! powered by Henry Ford LiveWell	1.1 Goal Setting (Behaviour) 4.1 Instruction on How to Perform A Behaviour 5.1 Information About Health Consequences 6.1 Demonstration of the Behaviour 6.2 Social Comparison 7.1 Prompts/Cues 8.1 Behavioural Practice/ Rehearsal 8.3 Habit Formation	**8**	**Yes**	1. Gamification Concept–to-User Communication: Mediated 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): Indirect 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only	1. Entertainment = 4 2. Interest = 4 3. Customisation = 3 4. Interactivity = 2 5. Target Group = 5 **TOTAL =3.6/5.0**	6. Performance = 4 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 5 **TOTAL = 4.25/5.0**	10. Layout = 4 11. Graphics = 4 12. Visual Appeal = 4 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals =4 15. Quality of Information = 5 16. Quantity of Information = 4 17. Visual Information = 4 18. Credibility = 4 19. Evidence Base = N/A **TOTAL = 4.33/5.0**	**App Quality Score = 3.92/5.0**
7 minute workouts with lazy monster PRO: daily fitness for kids and women	2.1 Monitoring of Behaviour by Others Without Feedback 6.1 Demonstration of the Behaviour 7.1 Prompts/Cues 8.3 Habit Formation 15.3 Focus on Past Success	**5**	**Yes**	1. Gamification Concept–to-User Communication: Mediated 2. User Identity: Virtual Character 3. Rewards: No 4. Competition (Between Users): No 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: No 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change	1. Entertainment = 4 2. Interest = 4 3. Customisation = 5 4. Interactivity = 5 5. Target Group = 4 **TOTAL =4.4/5.0**	6. Performance = 4 7. Ease of Use = 4 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.5/5.0**	10. Layout = 4 11. Graphics = 4 12. Visual Appeal = 4 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = N/A 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = 4 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.5/5.0**	**App Quality Score = 4.35/5.0**

				11. Level of Integration: Inherent 12. User Advancement: No					
AIMS – Improving Motor Skills	1.1 Goal Setting (Behaviour) 4.1 Instruction on How to Perform A Behaviour 7.1 Prompts/Cues 8.3 Habit Formation	**4**	**No**	N/A	1. Entertainment = 3 2. Interest = 3 3. Customisation = 3 4. Interactivity = 2 5. Target Group = 5 **TOTAL = 3.2/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.75/5.0**	10. Layout = 4 11. Graphics = 3 12. Visual Appeal = 3 **TOTAL = 3.33/5.0**	13. Accuracy of App Description (In App Store) = 4 14. Goals = 5 15. Quality of Information = 5 16. Quantity of Information = 4 17. Visual Information = N/A 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.5/5.0**	**App Quality Score = 3.95/5.0**
AR Runner	1.1 Goal Setting (Behaviour) 6.2 Social Comparison 8.3 Habit Formation 12.5 Adding Objects to the Environment	**4**	**No**	N/A	1. Entertainment = 4 2. Interest = 4 3. Customisation = 3 4. Interactivity = 2 5. Target Group = 4 **TOTAL = 3.4/5.0**	6. Performance = 3 7. Ease of Use = 4 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.25/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 4 **TOTAL = 4.33/5.0**	13. Accuracy of App Description (In App Store) = 4 14. Goals = 4 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = N/A 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.0/5.0**	**App Quality Score = 4.0/5.0**
Fitness RPG – Gamify Your Pedometer	1.1 Goal Setting (Behaviour) 2.2 Feedback on Behaviour 4.1 Instruction on How to Perform A Behaviour 5.1 Information About Health Consequences 6.1 Demonstration of the Behaviour 6.2 Social Comparison 7.1 Prompts/Cues 8.1 Behavioural Practice/Rehearsal 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome)	**11**	**Yes**	1. Gamification Concept–to-User Communication: Mediated 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): No 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive	1. Entertainment = 5 2. Interest = 5 3. Customisation = 4 4. Interactivity = 5 5. Target Group = 5 **TOTAL =4.8/5.0**	6. Performance = 3 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 4 **TOTAL = 4.25/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 5 15. Quality of Information = 3 16. Quantity of Information = 3 17. Visual Information = 4 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.0/5.0**	**App Quality Score = 4.43/5.0**

				10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Progressive					
Fitness Sense 2.0	1.1 Goal Setting (Behaviour) 2.2 Feedback on Behaviour 4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of Behaviour 6.2 Social Comparison 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome)	**8**	**Yes**	1. Gamification Concept–to-User Communication: Direct 2. User Identity: Self-Selected 3. Rewards: Internal 4. Competition (Between Users): Indirect 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Continuous 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only	1. Entertainment = 3 2. Interest = 3 3. Customisation = 3 4. Interactivity = 2 5. Target Group = 5 **TOTAL =3.2/5.0**	6. Performance = 4 7. Ease of Use = 4 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.5/5.0**	10. Layout = 4 11. Graphics = 4 12. Visual Appeal = 3 **TOTAL = 3.67/5.0**	13. Accuracy of App Description (In App Store) = 4 14. Goals = 5 15. Quality of Information = 3 16. Quantity of Information = 3 17. Visual Information = 3 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 3.6/5.0**	**App Quality Score = 3.74/5.0**
Fun fitness for kids	4.1 Instructions on How to Perform A Behaviour 6.1 Demonstration of Behaviour 8.3 Habit Formation 12.5 Adding Objects to the Environment	**4**	**No**	N/A	1. Entertainment = 5 2. Interest = 5 3. Customisation = 2 4. Interactivity = 2 5. Target Group = 5 **TOTAL =3.8/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.75/5.0**	10. Layout = 5 11. Graphics = 5 12. Visual Appeal = 3 **TOTAL = 4.33/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = N/A 15. Quality of Information = 4 16. Quantity of Information = 4 17. Visual Information = 5 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.5/5.0**	**App Quality Score = 4.39/5.0**
GeoPlay	1.1 Goal Setting (Behaviour) 4.1 Instruction on How to Perform A Behaviour 6.2 Social Comparison	**4**	**No**	N/A	1. Entertainment = 3 2. Interest = 3 3. Customisation = 3	6. Performance = 4 7. Ease of Use = 3 8. Navigation = 4 9. Gestural Design = 4	10. Layout = 3 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.33/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of	**App Quality Score = 3.95/5.0**

	12.5 Adding Objects to the Environment				4. Interactivity = 3 5. Target Group = 4 **TOTAL = 3.2/5.0**	**TOTAL = 3.75/5.0**		Information = N/A 16. Quantity of Information = N/A 17. Visual Information = N/A 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.5/5.0**	
GoNoodle Kids	4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of the Behaviour 7.1 Prompts/Cues 8.3 Habit Formation	**4**	**No**	N/A	1. Entertainment = 5 2. Interest = 5 3. Customisation = 5 4. Interactivity = 4 5. Target Group = 5 **TOTAL = 4.8/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.75/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = N/A 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = N/A 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 5.0/5.0**	**App Quality Score = 4.81/5.0**
Gorilla Workout: Build Muscle	1.1 Goal Setting (Behaviour) 2.3 Self-Monitoring of Behaviour 4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of the Behaviour 6.2 Social Comparison 7.1 Prompts/Cues 8.3 Habit Formation	**7**	**No**	N/A	1. Entertainment = 4 2. Interest = 4 3. Customisation = 5 4. Interactivity = 5 5. Target Group = 4 **TOTAL = 4.4/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.75/5.0**	10. Layout = 5 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 5.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 4 16. Quantity of Information = 4 17. Visual Information = 5 18. Credibility = 3 19. Evidence Base = N/A **TOTAL = 4.17/5.0**	**App Quality Score = 4.58/5.0**
Jump In the Exercise Board Game	1.1 Goal Setting (Behaviour) 2.2 Feedback on Behaviour 2.3 Self-Monitoring of Behaviour 4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of the Behaviour 6.2 Social Comparison	**8**	**Yes**	1. Gamification Concept–to-User Communication: Direct 2. User Identity: Self-Selected 3. Rewards: No 4. Competition (Between Users): Direct 5. Target Group: Healthy Individuals	1. Entertainment = 4 2. Interest = 4 3. Customisation = 3 4. Interactivity = 3 5. Target Group = 4 **TOTAL = 3.6/5.0**	6. Performance = 5 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 3 **TOTAL = 4.0/5.0**	10. Layout = 4 11. Graphics = 4 12. Visual Appeal = 4 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 4 16. Quantity of Information = 3	**App Quality Score = 3.86/5.0**

	8.3 Habit Formation 15.3 Focus on Past Success			6. Collaboration: No 7. Goal-Setting: Self-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only				17. Visual Information = 3 18. Credibility = 3 19. Evidence Base = N/A **TOTAL = 3.83/5.0**	
KID-FIT Music	7.1 Prompts/Cues	**1**	**No**	N/A	1. Entertainment = 1 2. Interest = 1 3. Customisation = 3 4. Interactivity = 3 5. Target Group = 3 **TOTAL = 2.2/5.0**	6. Performance = 1 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 5 **TOTAL = 3.5/5.0**	10. Layout = 3 11. Graphics = 3 12. Visual Appeal = 3 **TOTAL = 3.0/5.0**	13. Accuracy of App Description (In App Store) = 3 14. Goals = N/A 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = N/A 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 3.0/5.0**	**App Quality Score = 2.93/5.0**
Kids Dance PirateSessa: Castle	5.1 Information About Health Consequences 6.1 Demonstration of the Behaviour 8.3 Habit Formation	**3**	**No**	N/A	1. Entertainment = 3 2. Interest = 3 3. Customisation = 3 4. Interactivity = 2 5. Target Group = 4 **TOTAL = 3.0/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.75/5.0**	10. Layout = 3 11. Graphics = 5 12. Visual Appeal = 4 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = N/A 15. Quality of Information = 3 16. Quantity of Information = 3 17. Visual Information = 4 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 3.75/5.0**	**App Quality Score = 3.88/5.0**
Kids Dance PirateSessa Dungeon	5.1 Information About Health Consequences 6.1 Demonstration of the Behaviour 8.3 Habit Formation	**3**	**No**	N/A	1. Entertainment = 3 2. Interest = 3 3. Customisation = 3	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5	10. Layout = 3 11. Graphics = 5 12. Visual Appeal = 4 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = N/A 15. Quality of	**App Quality Score = 3.88/5.0**

					4. Interactivity = 2 5. Target Group = 4 **TOTAL = 3.0/5.0**	**TOTAL = 4.75/5.0**		Information = 3 16. Quantity of Information = 3 17. Visual Information = 4 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 3.75/5.0**	
Kids Exercise – Animal Workout	1.1 Goal Setting (Behaviour) 6.1 Demonstration of the Behaviour 7.1 Prompts/Cues 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome)	**6**	**Yes**	1. Gamification Concept–to-User Communication: Mediated 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): No 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only	1. Entertainment = 3 2. Interest = 3 3. Customisation = 4 4. Interactivity = 4 5. Target Group = 4 **TOTAL = 3.6/5.0**	6. Performance = 3 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 5 **TOTAL = 4.0/5.0**	10. Layout = 4 11. Graphics = 4 12. Visual Appeal = 5 **TOTAL = 4.33/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 5 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = 4 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.67/5.0**	**App Quality Score = 4.15/5.0**
Kung Fu for Kids	4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of Behaviour 8.3 Habit Formation	**3**	**No**	N/A	1. Entertainment = 5 2. Interest = 5 3. Customisation = 2 4. Interactivity = 2 5. Target Group = 5 **TOTAL = 3.8/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.75/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 3 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = N/A 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = 5 18. Credibility = 3 19. Evidence Base = N/A **TOTAL = 4.33/5.0**	**App Quality Score = 4.22/5.0**

Magic Kinder Official App – Free Kids Games	1.1 Goal Setting (Behaviour) 4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of the Behaviour 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome) 12.5 Adding Objects to the Environment	**7**	**Yes**	1. Gamification Concept–to-User Communication: Direct 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): No 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only	1. Entertainment = 5 2. Interest = 5 3. Customisation = 3 4. Interactivity = 2 5. Target Group = 5 **TOTAL = 4.0/5.0**	6. Performance = 3 7. Ease of Use = 3 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.0/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 4 16. Quantity of Information = 3 17. Visual Information = 5 18. Credibility = 4 19. Evidence Base = N/A **TOTAL = 4.17/5.0**	**App Quality Score = 4.21/5.0**
Map Monsters: Poke, Swipe, and Go	1.1 Goal Setting (Behaviour) 4.1 Instruction on How to Perform A Behaviour 7.1 Prompts/Cues 8.1 Behavioural Practice/Rehearsal 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome) 12.5 Adding Objects to the Environment	**8**	**Yes**	1. Gamification Concept–to-User Communication: Direct 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): No 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only	1. Entertainment = 3 2. Interest = 3 3. Customisation = 4 4. Interactivity = 2 5. Target Group = 5 **TOTAL = 3.4/5.0**	6. Performance = 4 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 3 **TOTAL = 3.75/5.0**	10. Layout = 3 11. Graphics = 4 12. Visual Appeal = 4 **TOTAL = 3.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 2 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = N/A 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 3.5/5.0**	**App Quality Score = 3.58/5.0**
NFL PLAY 60	1.1 Goal Setting (Behaviour) 2.2 Feedback on Behaviour	**10**	**Yes**	1. Gamification Concept–to-User Communication: Mediated	1. Entertainment = 5 2. Interest = 5	6. Performance = 4 7. Ease of Use = 5	10. Layout = 4 11. Graphics = 5	13. Accuracy of App Description (In App Store) = 5 14. Goals = 5	**App Quality Score = 4.57/5.0**

	2.3 Self-Monitoring of Behaviour 4.1 Instruction on How to Perform a Behaviour 6.1 Demonstration of the Behaviour 7.1 Prompts/Cues 8.3 Habit Formation 9.1 Credible Source 10.8 Incentive (Outcome) 10.10 Reward (Outcome)			2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): No 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only	3. Customisation = 4 4. Interactivity = 4 5. Target Group = 5 **TOTAL = 4.6/5.0**	8. Navigation = 4 9. Gestural Design = 5 **TOTAL = 4.5/5.0**	12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = 4 18. Credibility = 4 19. Evidence Base = N/A **TOTAL = 4.5/5.0**	
Physical Therapy for kids	4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of the Behaviour 8.3 Habit Formation	**3**	**No**	N/A	1. Entertainment = 2 2. Interest = 2 3. Customisation = 2 4. Interactivity = 2 5. Target Group = 4 **TOTAL = 2.4/5.0**	6. Performance = 3 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 4 **TOTAL = 4.25/5.0**	10. Layout = 4 11. Graphics = 3 12. Visual Appeal = 3 **TOTAL = 3.33/5.0**	13. Accuracy of App Description (In App Store) = 4 14. Goals = N/A 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = 4 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.0/5.0**	**App Quality Score = 3.50/5.0**
Push2Play – Active Games for Kids	1.1 Goal Setting (Behaviour) 4.1 Instruction on How to Perform A Behaviour 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome) 12.5 Adding Objects to the Environment	**6**	**Yes**	1. Gamification Concept–to-User Communication: Direct 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): Direct 5. Target Group: Healthy Individuals 6. Collaboration: Cooperative 7. Goal-Setting: Externally-Set 8. Narrative: Episodical	1. Entertainment = 5 2. Interest = 5 3. Customisation = 4 4. Interactivity = 3 5. Target Group = 5 **TOTAL = 4.4/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 4 **TOTAL = 4.5/5.0**	10. Layout = 4 11. Graphics = 4 12. Visual Appeal = 4 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 4 16. Quantity of Information = 4 17. Visual Information = 4 18. Credibility = 4 19. Evidence Base = N/A	**App Quality Score = 4.27/5.0**

				9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Presentation Only				**TOTAL = 4.17/5.0**	
Skipping Skills	4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of the Behaviour 12.5 Adding Objects to the Environment	**3**	**No**	N/A	1. Entertainment = 4 2. Interest = 4 3. Customisation = 3 4. Interactivity = 2 5. Target Group = 5 **TOTAL = 3.6/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.75/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = N/A 15. Quality of Information = 4 16. Quantity of Information = 4 17. Visual Information = 5 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.5/5.0**	**App Quality Score = 4.38/5.0**
Soccer Exercise for Kids	1.1 Goal Setting (Behaviour) 4.1 Instruction on How to Perform A Behaviour 6.1 Demonstration of Behaviour 6.2 Social Comparison 8.3 Habit Formation 12.5 Adding Objects to the Environment	**6**	**No**	N/A	1. Entertainment = 4 2. Interest = 4 3. Customisation = 2 4. Interactivity = 2 5. Target Group = 5 **TOTAL = 3.4/5.0**	6. Performance = 4 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.75/5.0**	10. Layout = 4 11. Graphics = 3 12. Visual Appeal = 3 **TOTAL = 3.33/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 4 16. Quantity of Information = 3 17. Visual Information = 4 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.0/5.0**	**App Quality Score = 3.87/5.0**
Sworkit Fitness – Workouts & Exercise Plans App	1.1 Goal Setting (Behaviour) 2.2 Feedback on Behaviour 4.1 Instructions on How to Perform A Behaviour 6.1 Demonstration of the Behaviour 7.1 Prompts/Cues 8.3 Habit Formation 10.4 Social Reward	**9**	**No**	N/A	1. Entertainment = 5 2. Interest = 5 3. Customisation = 5 4. Interactivity = 5 5. Target Group = 4 **TOTAL = 4.8/5.0**	6. Performance = 5 7. Ease of Use = 5 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 5.0/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 5 16. Quantity of Information = 4 17. Visual Information = 5	**App Quality Score = 4.7/5.0**

	12.5 Adding Objects to the Environment 15.3 Focus on Past Success							18. Credibility = 3 19. Evidence Base = N/A **TOTAL = 4.33/5.0**	
TopYa! Active	1.1 Goal Setting (Behaviour) 2.6 Biofeedback 4.1 Instructions on How to Perform A Behaviour 6.1 Demonstration of the Behaviour 6.2 Social Comparison 7.1 Prompts/Cues 8.1 Behavioural Practice/Rehearsal 8.3 Habit Formation 10.1 Material Incentive (Behaviour) 10.2 Material Reward (Behaviour) 10.8 Incentive (Outcome) 10.10 Reward (Outcome) 12.5 Adding Objects to the Environment	**13**	**No**	N/A	1. Entertainment = 5 2. Interest = 5 3. Customisation = 4 4. Interactivity = 5 5. Target Group = 4 **TOTAL = 4.8/5.0**	6. Performance = 3 7. Ease of Use = 4 8. Navigation = 5 9. Gestural Design = 5 **TOTAL = 4.25/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 4 **TOTAL = 4.33/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 4 16. Quantity of Information = 4 17. Visual Information = 5 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.4/5.0**	**App Quality Score = 4.45/5.0**
VR Fitness Sapporo	2.2 Feedback on Behaviour 8.3 Habit Formation 12.5 Adding Objects to the Environment	**3**	**No**	N/A	1. Entertainment = 3 2. Interest = 3 3. Customisation = 2 4. Interactivity = 2 5. Target Group = 4 **TOTAL = 2.8/5.0**	6. Performance = 4 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 5 **TOTAL = 4.0/5.0**	10. Layout = 3 11. Graphics = 5 12. Visual Appeal = 4 **TOTAL = 4.0/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = N/A 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = N/A 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 5.0/5.0**	**App Quality Score = 3.16/5.0**
Walkr – A Gamified Fitness App	1.1 Goal Setting (Behaviour) 2.2 Feedback on Behaviour 4.1 Instruction on How to Perform A Behaviour 6.2 Social Comparison 7.1 Prompts/Cues 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome)	**10**	**Yes**	1. Gamification Concept–to-User Communication: Direct 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): No 5. Target Group: Healthy Individuals	1. Entertainment = 5 2. Interest = 5 3. Customisation = 4 4. Interactivity = 5 5. Target Group = 5 **TOTAL = 4.8/5.0**	6. Performance = 5 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 4 **TOTAL = 4.25/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 4 16. Quantity of Information = 3 17. Visual Information = 4	**App Quality Score = 4.43/5.0**

	12.5 Adding Objects to the Environment 15.3 Focus on Past Success			6. Collaboration: Cooperative 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Progressive				18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.0/5.0**	
Walkr: Fitness Space Adventure	1.1 Goal Setting (Behaviour) 2.2 Feedback on Behaviour 4.1 Instruction on How to Perform A Behaviour 6.2 Social Comparison 7.1 Prompts/Cues 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome) 12.5 Adding Objects to the Environment 15.3 Focus on Past Success	**10**	**Yes**	1. Gamification Concept–to-User Communication: Direct 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): No 5. Target Group: Healthy Individuals 6. Collaboration: Cooperative 7. Goal-Setting: Externally-Set 8. Narrative: Episodical 9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Progressive	1. Entertainment = 5 2. Interest = 5 3. Customisation = 4 4. Interactivity = 5 5. Target Group = 5 **TOTAL = 4.8/5.0**	6. Performance = 5 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 4 **TOTAL = 4.25/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = 4 16. Quantity of Information = 3 17. Visual Information = 4 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.0/5.0**	**App Quality Score = 4.43/5.0**
Wokamon – Fitness Game	1.1 Goal Setting (Behaviour) 2.2 Feedback on Behaviour 4.1 Instruction on How to Perform A Behaviour 8.3 Habit Formation 10.8 Incentive (Outcome) 10.10 Reward (Outcome) 12.5 Adding Objects to the Environment 15.3 Focus on Past Success	**8**	**Yes**	1. Gamification Concept–to-User Communication: Direct 2. User Identity: Virtual Character 3. Rewards: Internal 4. Competition (Between Users): No 5. Target Group: Healthy Individuals 6. Collaboration: No 7. Goal-Setting: Externally-Set 8. Narrative: Episodical	1. Entertainment = 4 2. Interest = 4 3. Customisation = 3 4. Interactivity = 3 5. Target Group = 5 **TOTAL = 3.8/5.0**	6. Performance = 3 7. Ease of Use = 4 8. Navigation = 4 9. Gestural Design = 5 **TOTAL = 4.0/5.0**	10. Layout = 4 11. Graphics = 5 12. Visual Appeal = 5 **TOTAL = 4.67/5.0**	13. Accuracy of App Description (In App Store) = 5 14. Goals = 4 15. Quality of Information = N/A 16. Quantity of Information = N/A 17. Visual Information = 5 18. Credibility = N/A 19. Evidence Base = N/A **TOTAL = 4.67/5.0**	**App Quality Score = 4.29/5.0**

				9. Reinforcement: Positive 10. Persuasive Intent: Behaviour Change 11. Level of Integration: Inherent 12. User Advancement: Progressive					
Note: BCTs Behaviour Change Techniques, MARS Mobile Application Rating Scale									

A2. Table 9. Gamification Technique Characteristics

Gamification Technique	Characteristic #1	Characteristic #2	Characteristic #3
1. Gamification Concept-to-User Communication	Direct (8/13 apps, 61.5%)	Mediated (5/13 apps, 38.5%)	
2. User Identity	Virtual Character (11/13 apps, 84.6%)	Self-Selected (2/13 apps, 15.4%)	
3. Rewards	Internal (11/13 apps, 84.6%)	External (0/13 apps, 0%)	No (2/13 apps, 15.4%)
4. Competition	Direct (2/13 apps, 15.4%)	Indirect (2/13 app, 15.4%)	No (9/13 apps, 69.2%)
5. Target Group	Patient (0/13 apps, 0%)	Healthy Individuals (13/13 apps, 100%)	Health Professionals (0/13 apps, 0%)
6. Collaboration	Cooperative (3/13 apps, 23.1%)	Supportive Only (0/13 apps, 0%)	No (10/13 apps, 76.9%)
7. Goal Setting	Self-Set (1/13 apps, 7.7%)	Externally Set (11/13 apps, 84.6%)	No (1/13 apps, 7.7%)
8. Narrative	Continuous (1/13 apps, 7.7%)	Episodical (12/13 apps, 92.3%)	
9. Reinforcement	Positive (13/13 apps, 100%)	Positive-Negative (0/13 apps, 0%)	
10. Persuasive Intent	Compliance Change (0/13 apps, 0%)	Behaviour Change (13/13 apps, 0%)	Attitude Change (0/13 apps, 0%)
11. Level of Integration	Independent (0/13 apps, 0%)	Inherent (13/13 apps, 100%)	
12. User Advancement	Presentation Only (8/13 apps, 61.5%)	Progressive (4/13 apps, 30.8%)	No (1/13 apps, 7.7%)
Note: The Gamification Techniques occurred in 13 of 29 apps.			

A3. Table 10. Average Quality Scores Per Section and Overall

	Overall App Quality Score	Section A (Engagement)	Section B (Functionality)	Section C (Aesthetics)	Section D (Information)
Average Quality Score	3.92 + 4.35 + 3.95 + 4.0 + 4.43 + 3.74 + 4.39 + 3.95 + 4.81 + 4.58 + 3.86 + 2.93 + 3.88 + 3.88 + 4.15 + 4.22 + 4.21 + 3.58 + 4.57 + 3.50 + 4.27 + 4.38 + 3.87 + 4.7 + 4.45 + 3.16 + 4.43 + 4.43 + 4.29 = **4.10/5.0**	3.6 + 4.4 + 3.2 + 3.4 + 4.8 + 3.2 + 3.8 + 3.2 + 4.8 + 4.4 + 3.6 + 2.2 + 3.0 +3.0 + 3.6 + 3.8 + 4.0 + 3.4 + 4.6 + 2.4 + 4.4 + 3.6 + 3.4 + 4.8 + 4.8 + 2.8 + 4.8 + 4.8 + 3.8 = **3.78/5.0**	4.25 + 4.5 + 4.75 + 4.25 + 4.25 + 4.5 + 4.75 + 3.75 + 4.75 + 4.75 + 4.0 + 3.5 + 4.75 + 4.75 + 4.0 + 4.75 + 4.0 + 3.75 + 4.5 + 4.25 + 4.5 + 4.75 + 4.75 + 5.0 + 4.25 + 4.0 + 4.25 + 4.25 + 4.0 = **4.36/5.0**	4.0 + 4.0 + 3.33 + 4.33 + 4.67 + 3.67 + 4.33 + 4.33 + 4.67 + 5.0 + 4.0 + 3.0 + 4.0 + 4.0 + 4.33 + 4.0 + 4.67 + 3.67 + 4.67 + 3.33 + 4.0 + 4.67 + 3.33 + 4.67 + 4.33 + 4.0 + 4.67 + 4.67 + 4.67 = **4.17/5.0**	4.33 + 4.5 + 4.5 + 4.0 + 4.0 + 3.6 + 4.5 + 4.5 + 5.0 + 4.17 + 3.83 + 3.0 + 3.75 + 3.75 + 4.67 + 4.33 + 4.17 + 3.5 + 4.5 + 4.0 + 4.17 + 4.5 + 4.0 + 4.33 + 4.4 + 5.0 + 4.0 + 4.0 + 4.67 = **4.20/5.0**

A4. Table 11. Gamified Vs. Non-Gamified Apps

	Gamified Apps (13/29, 44.8%)	Non-Gamified Apps (16/29, 55.2%)
Behaviour Change Techniques	8 + 5 + 11 + 8 + 8 + 6 + 7 + 8 + 10 + 6 + 10 + 10 + 8 = **8**	4 + 4 + 4 + 4 + 4 + 7 + 1 + 3 + 3 + 3 + 3 + 3 + 6 + 9 + 13 + 3 = **5**
Overall App Quality Score	3.92 + 4.35 + 4.43 + 3.74 + 3.86 + 4.15 + 4.21 + 3.58 + 4.57 + 4.27 + 4.43 + 4.43 + 4.29 = **4.17/5.0**	3.95 + 4.0 + 4.39 + 3.95 + 4.81 + 4.58 + 2.93 + 3.88 + 3.88 + 4.22 + 3.50 + 4.38 + 3.87 + 4.7 + 4.45 + 3.16 = **4.04/5.0**

Appendix B. Documents

Appendix B1. PRISMA Checklist 2009

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

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Appendix B2. Quasi-PRISMA Checklist 2009 for Environmental Scan

Section/topic	#	Checklist item	Reported on page #
METHODS			
Environmental Scan	1	Describe the process of an environmental scan and what environmental scans are used for. Describe the process used in this specific environmental scan design. Discuss the research questions that will be answered using this design.	
App Search Protocol	2	Indicate if a search protocol exists and what it encompasses, by the way of different steps or stages. If available, provide registration information including registration number.	
App Screening and Review	3	Identify the search terms and databases used the conduct the environmental scan. Provide detail on the process of searching and screening of apps to narrow down results and apps found.	
Search Criteria	4	Establish the search terms that will be used to conduct the environmental scan app search and explain why they have been chosen.	
Search Databases	5	Discuss the search engines that will be used for the app search and why those engines will be used over others. Further discuss in detail the search protocol, including the inclusion/exclusion factors in the different stages of the app search procedure.	
Data Management	6	Explain in detail the process by which the apps found will be organized (i.e., via spreadsheet), and discuss which elements will be included on the spreadsheet (i.e., such as cost, name, developer, etc.).	
Synthesis of Results	7	Identify any forms of statistical analysis that will be conducted and applied to the results found from this search. Also identify which program and software these forms of analysis will be conducted on.	
Risk of Bias	8	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	

Appendix B3. Final Exclusion Criteria

Final Exclusion Criteria

Apps will be further excluded before being downloaded based off of specific concepts and words found within the title. If a researcher is unsure of whether to include or exclude an app, they may search the app and read the description for these key concepts and words. This will assist in ensuring apps are geared towards children specifically. Key words and concepts to consider are:

1) **Fitness Challenge**
2) **Body Exercises**
3) **Weight Loss**
4) **Push Ups**
5) **Exercise Challenge**
6) **Workout Challenge**
7) **Bodybuilding/Powerlifting/Weight Training**
8) **Activity Tracker**
9) **Fitness Tracker**
10) **Beep Test/Fitness Assessment**
11) **Yoga/Mat Exercises/Workout**
12) **Nutrition content**
13) **Inappropriate words and/or pictures for children (ex. sexy, etc.)**
14) **Language children would not comprehend (ex. vigorous, cardiovascular health, etc.)**
15) **Inappropriate content for children (ex. supplement use, menstruation, walking around cities, money/betting etc.)**
16) **Discusses BMI (could lead to negative self-image in children)**
17) **Men and Women**
18) **Use of points cards/credit cards or to collect gift cards**
19) **Uses video chat with a fitness coach**
20) **Content geared towards teachers not children**
21) **Minimal physical activity content**
22) **No longer available**

If the app title includes the word "**kids**" the app will be included. If the reviewer is inconclusive on the app's age range based off of its title, the app name can be searched in the respective store and the description of the app can be examined. Exclusion can be applied if the app is for a fitness challenge, uses inappropriate words for children (ex. sexy), or would consist of language children would not comprehend (vigorous exercises, cardiovascular health, etc.). If an app is searched and is found to be no longer available this should be stated. If the description is required to be read, the reviewer must state this within the excel file in the "Description Checked" column.

Appendix B4. Behaviour Change Taxonomy Certificate


BCT Taxonomy v1

Online Training

CERTIFICATE OF COMPLETION

This is to certify that the holder of this certificate has:

Completed full online training at: www.bct-taxonomy.com and has achieved coding competence in use of BCTTv1 to specify the content of complex behaviour change interventions

Certified by:

The BCTTv1 Project Team

and the UCL Centre for Behaviour Change

For further training opportunities, see www.ucl.ac.uk/behaviour-change

CBC UCL Centre for Behaviour Change

Appendix B5. Mobile Application Rating Scale (MARS)

App Quality Ratings

The Rating scale assesses app quality on four dimensions. All items are rated on a 5-point scale from "1.Inadequate" to "5.Excellent". Circle the number that most accurately represents the quality of the app component you are rating. Please use the descriptors provided for each response category.

SECTION A

Engagement – fun, interesting, customisable, interactive (e.g. sends alerts, messages, reminders, feedback, enables sharing), well-targeted to audience

1. Entertainment: Is the app fun/entertaining to use? Does it use any strategies to increase engagement through entertainment (e.g. through gamification)?

1 Dull, not fun or entertaining at all
2 Mostly boring
3 OK, fun enough to entertain user for a brief time (< 5 minutes)
4 Moderately fun and entertaining, would entertain user for some time (5-10 minutes total)
5 Highly entertaining and fun, would stimulate repeat use

2. Interest: Is the app interesting to use? Does it use any strategies to increase engagement by presenting its content in an interesting way?

1 Not interesting at all
2 Mostly uninteresting
3 OK, neither interesting nor uninteresting; would engage user for a brief time (< 5 minutes)
4 Moderately interesting; would engage user for some time (5-10 minutes total)
5 Very interesting, would engage user in repeat use

3. Customisation: Does it provide/retain all necessary settings/preferences for apps features (e.g. sound, content, notifications, etc.)?

1 Does not allow any customisation or requires setting to be input every time
2 Allows insufficient customisation limiting functions
3 Allows basic customisation to function adequately
4 Allows numerous options for customisation
5 Allows complete tailoring to the individual's characteristics/preferences, retains all settings

4. Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)? Note: these functions need to be customisable and not overwhelming in order to be perfect.

1 No interactive features and/or no response to user interaction
2 Insufficient interactivity, or feedback, or user input options, limiting functions
3 Basic interactive features to function adequately
4 Offers a variety of interactive features/feedback/user input options
5 Very high level of responsiveness through interactive features/feedback/user input options

5. Target group: Is the app content (visual information, language, design) appropriate for your target audience?

1 Completely inappropriate/unclear/confusing
2 Mostly inappropriate/unclear/confusing
3 Acceptable but not targeted. May be inappropriate/unclear/confusing
4 Well-targeted, with negligible issues
5 Perfectly targeted, no issues found

A. Engagement mean score = ________

SECTION B

Functionality – app functioning, easy to learn, navigation, flow logic, and gestural design of app

6. Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?

1 App is broken; no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.)
2 Some functions work, but lagging or contains major technical problems
3 App works overall. Some technical problems need fixing/Slow at times
4 Mostly functional with minor/negligible problems
5 Perfect/timely response; no technical bugs found/contains a 'loading time left' indicator

7. Ease of use: How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?

1 No/limited instructions; menu labels/icons are confusing; complicated
2 Useable after a lot of time/effort
3 Useable after some time/effort
4 Easy to learn how to use the app (or has clear instructions)
5 Able to use app immediately; intuitive; simple

8. Navigation: Is moving between screens logical/accurate/appropriate/ uninterrupted; are all necessary screen links present?

1 Different sections within the app seem logically disconnected and random/confusing/navigation is difficult
2 Usable after a lot of time/effort
3 Usable after some time/effort
4 Easy to use or missing a negligible link
5 Perfectly logical, easy, clear and intuitive screen flow throughout, or offers shortcuts

9. Gestural design: Are interactions (taps/swipes/pinches/scrolls) consistent and intuitive across all components/screens?

1 Completely inconsistent/confusing
2 Often inconsistent/confusing
3 OK with some inconsistencies/confusing elements
4 Mostly consistent/intuitive with negligible problems
5 Perfectly consistent and intuitive

B. Functionality mean score = ________

SECTION C

Aesthetics – graphic design, overall visual appeal, colour scheme, and stylistic consistency

10. Layout: Is arrangement and size of buttons/icons/menus/content on the screen appropriate or zoomable if needed?

1 Very bad design, cluttered, some options impossible to select/locate/see/read device display not optimised
2 Bad design, random, unclear, some options difficult to select/locate/see/read
3 Satisfactory, few problems with selecting/locating/seeing/reading items or with minor screen-size problems
4 Mostly clear, able to select/locate/see/read items
5 Professional, simple, clear, orderly, logically organised, device display optimised. Every design component has a purpose

11. **Graphics: How high is the quality/resolution of graphics used for buttons/icons/menus/content?**
    1 Graphics appear amateur, very poor visual design - disproportionate, completely stylistically inconsistent
    2 Low quality/low resolution graphics; low quality visual design – disproportionate, stylistically inconsistent
    3 Moderate quality graphics and visual design (generally consistent in style)
    4 High quality/resolution graphics and visual design – mostly proportionate, stylistically consistent
    5 Very high quality/resolution graphics and visual design - proportionate, stylistically consistent throughout

12. **Visual appeal: How good does the app look?**
    1 No visual appeal, unpleasant to look at, poorly designed, clashing/mismatched colours
    2 Little visual appeal – poorly designed, bad use of colour, visually boring
    3 Some visual appeal – average, neither pleasant, nor unpleasant
    4 High level of visual appeal – seamless graphics – consistent and professionally designed
    5 As above + very attractive, memorable, stands out; use of colour enhances app features/menus

C. Aesthetics mean score = ___________

SECTION D

Information – Contains high quality information (e.g. text, feedback, measures, references) from a credible source. Select N/A if the app component is irrelevant.

13. **Accuracy of app description (in app store): Does app contain what is described?**
    1 Misleading. App does not contain the described components/functions. Or has no description
    2 Inaccurate. App contains very few of the described components/functions
    3 OK. App contains some of the described components/functions
    4 Accurate. App contains most of the described components/functions
    5 Highly accurate description of the app components/functions

14. **Goals: Does app have specific, measurable and achievable goals (specified in app store description or within the app itself)?**
    N/A Description does not list goals, or app goals are irrelevant to research goal (e.g. using a game for educational purposes)
    1 App has no chance of achieving its stated goals
    2 Description lists some goals, but app has very little chance of achieving them
    3 OK. App has clear goals, which may be achievable.
    4 App has clearly specified goals, which are measurable and achievable
    5 App has specific and measurable goals, which are highly likely to be achieved

15. **Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app?**
    N/A There is no information within the app
    1 Irrelevant/inappropriate/incoherent/incorrect
    2 Poor. Barely relevant/appropriate/coherent/may be incorrect
    3 Moderately relevant/appropriate/coherent/and appears correct
    4 Relevant/appropriate/coherent/correct
    5 Highly relevant, appropriate, coherent, and correct

16. **Quantity of information: Is the extent coverage within the scope of the app; and comprehensive but concise?**
    N/A There is no information within the app
    1 Minimal or overwhelming
    2 Insufficient or possibly overwhelming
    3 OK but not comprehensive or concise
    4 Offers a broad range of information, has some gaps or unnecessary detail; or has no links to more information and resources
    5 Comprehensive and concise; contains links to more information and resources

17. **Visual information: Is visual explanation of concepts – through charts/graphs/images/videos, etc. – clear, logical, correct?**
    N/A There is no visual information within the app (e.g. it only contains audio, or text)
    1 Completely unclear/confusing/wrong or necessary but missing
    2 Mostly unclear/confusing/wrong
    3 OK but often unclear/confusing/wrong
    4 Mostly clear/logical/correct with negligible issues
    5 Perfectly clear/logical/correct

18. **Credibility: Does the app come from a legitimate source (specified in app store description or within the app itself)?**
    1 Source identified but legitimacy/trustworthiness of source is questionable (e.g. commercial business with vested interest)
    2 Appears to come from a legitimate source, but it cannot be verified (e.g. has no webpage)
    3 Developed by small NGO/institution (hospital/centre, etc.) /specialised commercial business, funding body
    4 Developed by government, university or as above but larger in scale
    5 Developed using nationally competitive government or research funding (e.g. Australian Research Council, NHMRC)

19. **Evidence base: Has the app been trialled/tested; must be verified by evidence (in published scientific literature)?**
    N/A The app has not been trialled/tested
    1 The evidence suggests the app does not work
    2 App has been trialled (e.g., acceptability, usability, satisfaction ratings) and has partially positive outcomes in studies that are not randomised controlled trials (RCTs), or there is little or no contradictory evidence.
    3 App has been trialled (e.g., acceptability, usability, satisfaction ratings) and has positive outcomes in studies that are not RCTs, and there is no contradictory evidence.
    4 App has been trialled and outcome tested in 1-2 RCTs indicating positive results
    5 App has been trialled and outcome tested in $\geq$ 3 high quality RCTs indicating positive results

D. Information mean score = __________ *

* Exclude questions rated as "N/A" from the mean score calculation.

Scoring

App quality scores for

SECTION

A: Engagement Mean Score = ________________________

B: Functionality Mean Score = ________________________

C: Aesthetics Mean Score = ________________________

D: Information Mean Score = ________________________

App quality mean Score = ________________________

Appendix B6. Behaviour Change Techniques

BCT Taxonomy (v1): 93 hierarchically-clustered techniques

Page	Grouping and BCTs
1	**1. Goals and planning** 1.1. Goal setting (behavior) 1.2. Problem solving 1.3. Goal setting (outcome) 1.4. Action planning 1.5. Review behavior goal(s) 1.6. Discrepancy between current behavior and goal 1.7. Review outcome goal(s) 1.8. Behavioral contract 1.9. Commitment
3	**2. Feedback and monitoring** 2.1. Monitoring of behavior by others without feedback 2.2. Feedback on behaviour 2.3. Self-monitoring of behaviour 2.4. Self-monitoring of outcome(s) of behaviour 2.5. Monitoring of outcome(s) of behavior without feedback 2.6. Biofeedback 2.7. Feedback on outcome(s) of behavior
5	**3. Social support** 3.1. Social support (unspecified) 3.2. Social support (practical) 3.3. Social support (emotional)
6	**4. Shaping knowledge** 4.1. Instruction on how to perform the behavior 4.2. Information about Antecedents 4.3. Re-attribution 4.4. Behavioral experiments
7	**5. Natural consequences** 5.1. Information about health consequences 5.2. Salience of consequences 5.3. Information about social and environmental consequences 5.4. Monitoring of emotional consequences 5.5. Anticipated regret 5.6. Information about emotional consequences
8	**6. Comparison of behaviour** 6.1. Demonstration of the behavior 6.2. Social comparison 6.3. Information about others' approval
9	**7. Associations** 7.1. Prompts/cues 7.2. Cue signalling reward 7.3. Reduce prompts/cues 7.4. Remove access to the reward 7.5. Remove aversive stimulus 7.6. Satiation 7.7. Exposure 7.8. Associative learning
10	**8. Repetition and substitution** 8.1. Behavioral practice/rehearsal 8.2. Behavior substitution 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of target behavior 8.7. Graded tasks
11	**9. Comparison of outcomes** 9.1. Credible source 9.2. Pros and cons 9.3. Comparative imagining of future outcomes
12	**10. Reward and threat** 10.1. Material incentive (behavior) 10.2. Material reward (behavior) 10.3. Non-specific reward 10.4. Social reward 10.5. Social incentive 10.6. Non-specific incentive 10.7. Self-incentive 10.8. Incentive (outcome) 10.9. Self-reward 10.10. Reward (outcome) 10.11. Future punishment
15	**11. Regulation** 11.1. Pharmacological support 11.2. Reduce negative emotions 11.3. Conserving mental resources 11.4. Paradoxical instructions
16	**12. Antecedents** 12.1. Restructuring the physical environment 12.2. Restructuring the social environment 12.3. Avoidance/reducing exposure to cues for the behavior 12.4. Distraction 12.5. Adding objects to the environment 12.6. Body changes
17	**13. Identity** 13.1. Identification of self as role model 13.2. Framing/reframing 13.3. Incompatible beliefs 13.4. Valued self-identify 13.5. Identity associated with changed behavior
18	**14. Scheduled consequences** 14.1. Behavior cost 14.2. Punishment 14.3. Remove reward 14.4. Reward approximation 14.5. Rewarding completion 14.6. Situation-specific reward 14.7. Reward incompatible behavior 14.8. Reward alternative behavior 14.9. Reduce reward frequency 14.10. Remove punishment
19	**15. Self-belief** 15.1. Verbal persuasion about capability 15.2. Mental rehearsal of successful performance 15.3. Focus on past success 15.4. Self-talk
19	**16. Covert learning** 16.1. Imaginary punishment 16.2. Imaginary reward 16.3. Vicarious consequences

Appendix B7. Gamification Techniques (Dimensions and Characteristics)

<table>
<tr><th>Dimension</th><th colspan="6">Characteristics</th></tr>
<tr><td>Gamification concept-to-user communication</td><td colspan="3">Direct</td><td colspan="3">Mediated</td></tr>
<tr><td>User identity</td><td colspan="3">Virtual character</td><td colspan="3">Self-selected</td></tr>
<tr><td>Rewards</td><td colspan="2">Internal</td><td colspan="2">Internal and external</td><td colspan="2">No</td></tr>
<tr><td>Competition</td><td colspan="2">Direct</td><td colspan="2">Indirect</td><td colspan="2">No</td></tr>
<tr><td>Target group</td><td colspan="2">Patients</td><td colspan="2">Healthy individuals</td><td colspan="2">Health professionals</td></tr>
<tr><td>Collaboration</td><td colspan="2">Cooperative</td><td colspan="2">Supportive only</td><td colspan="2">No</td></tr>
<tr><td>Goal-setting</td><td colspan="3">Self-set</td><td colspan="3">Externally set</td></tr>
<tr><td>Narrative</td><td colspan="3">Continuous</td><td colspan="3">Episodical</td></tr>
<tr><td>Reinforcement</td><td colspan="3">Positive</td><td colspan="3">Positive-negative</td></tr>
<tr><td>Level of integration</td><td colspan="3">Independent</td><td colspan="3">Inherent</td></tr>
<tr><td>Persuasive intent</td><td colspan="2">Compliance change</td><td colspan="2">Behavior change</td><td colspan="2">Attitude change</td></tr>
<tr><td>User advancement</td><td colspan="2">Presentation only</td><td colspan="2">Progressive</td><td colspan="2">No</td></tr>
</table>

Appendix B8. Focus Group Interview Guide with Probes

Focus Group Interview Guide

1. What is your perspective and level of experience on mobile applications in the classroom to facilitate learning?
   Probes: positive, negative, beneficial, lack of time

2. If you were to use a physical activity based mobile application in your classroom for daily physical activity (DPA) what main features would be most useful to yourself?
   Probes: teacher section, activity guide, student games section

3. What main barriers, if any, prevent you for conducting DPA sessions every day?
   Probes: lack of time, lack of resources, lack of space, negative behaviours

4. What activities, exercises, or games do you use when you run a typical DPA session?
   Probes: charades, physical activity, heads up seven up

5. Are you provided with the proper resources to conduct DPA sessions and do you feel confident in conducting them? If so, what do these resources contain?
   Probes: OPHEA games, not trained enough, low confidence

Appendix B9. Letter of Information for Focus Group Interviews

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY | Faculty of Health Sciences

2000 Simcoe Street North
Oshawa, Ontario
L1H 7K4

YY/MM/DD

Dear ___________________,

We are teachers and researchers at the University of Ontario Institute of Technology (UOIT). We have a partnership with the school district and local community services to study the use of new educational tech tools (apps in an online environment) that might be able to assist with students' comprehensive (whole-self) development. More specifically, we are interested in how a suite of educational apps can help students build confidence and competencies in three domains: 1) Cognitive (Mind Zone); 2} Social-Emotional (Community Zone); and, 3} Physical (Body Zone) and support the learning of students, teachers, and community.

We are asking for your consent for you to participate in our research project called, "There's an App for That".

This project includes the use of a digital environmental containing various apps and resources that students, teachers, and parents can access. The apps will help with the teaching and learning of items like physical wellbeing.

2000 Simcoe Street Norther, Oshawa, Ontario L1H 7K4 Canada I 905.721.3181 I education.uoit.ca

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY | Faculty of Health Sciences

Collection of Information

Information will be collected at various times during the project. We will gather information in the following ways:

- We would like to audio record you

A summary of the research tools and time allotted for each tool for you include:

- Semi-structured interviews: ~ 30-45 minutes

We will only collect data from you if and only where you have provided consent. Findings from this project may be published in journals and presented at conferences.

Voluntary Participation and Withdrawal

You may withdraw from the study at any time without penalty. Although you, as the teacher, may use the EduApps activities and products generated from these activities for assessment and evaluation purposes, the research component is not tied to any grading or student evaluation of any kind. Participant in the research is entirely optional.

Confidentiality

The information will not be stored with personal identifiers in any recorded or published comments. The transcripts of classroom proceedings, as well as any other data collected will be stored securely at UOIT under the researchers' supervision and will be destroyed after five years. By consenting to participate, you do not waive any legal rights or recourse.

2000 Simcoe Street Norther, Oshawa, Ontario L1H 7K4 Canada I 905.721.3181 I education.uoit.ca

Participation Benefits and Risks

Potential benefits for participation in this study for you include: learning new digital tools; learning strategies for physical health.

Potential risks for you as the teachers include: feeling pressured to participate because your principal has approached you with this opportunity. However, your principal has assured us that there are no positive or negative implications for choosing to or for choosing not to participate in this research.

Your signature on the consent form indicates that you have read this letter, understand its contents, and authorize the participation of yourself in this research project.

If you have questions about this project, feel free to call project lead Dr. Janette Hughes (905.721.8668 ext. 2875) or the UOIT Research Ethics and Compliance Officer, who can provide answers to pertinent question about the research participants' rights (compliance@uoit.ca (905) 721-8668, ext. 3693). Thank you for considering participation in this research study.

Dr. Janette Hughes, UOIT

2000 Simcoe Street Norther, Oshawa, Ontario L1H 7K4 Canada | 905.721.3181 | education.uoit.ca

Appendix B10. Consent Form for Focus Group Interviews

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY | Faculty of Health Sciences

"There's An App For That"

Teacher Consent Form

I have read the Letter of Information for the above titled research study, I understand the purpose of the research and my questions have been answered to my satisfaction.

I understand that I have the right to withdraw myself from the study at any time and that declination from participating in the project will not have any negative consequences for me. I also understand that the information collected is for educational/research purposes only. By Signing below, I give consent to participate in the research study.

School Name: ____________________

Name (please print): ____________________

Signature: ____________________

Date: ____________________

For the purposes of research, I give consent to be recorded:

- ☐ Audio

Participant Concerns and Reporting:

If you have any questions concerning the research study or experience any discomfort related to the study, please contact the research Dr. Janette Hughes at janette.hughes@uoit.ca.

2000 Simcoe Street Norther, Oshawa, Ontario L1H 7K4 Canada | 905.721.3181 | education.uoit.ca

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY | Faculty of Health Sciences

Any questions regarding your rights as a participant, complaints, or adverse events may be addressed to Research Ethics Board through the Research Ethics Coordinator – researchethics@uoit.ca or 905.721.8668 x. 3693.

This study has been approved by the UOIT Research Ethics Board REB [14426] on [14/03/2017].

2000 Simcoe Street Norther, Oshawa, Ontario L1H 7K4 Canada | 905.721.3181 | education.uoit.ca