Role of School Outdoor Play Structures on the Physical Activity Level of Children During Recess: A Pilot Study

by

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Abstract

The contribution of outdoor play structures to moderate to vigorous physical activity (MVPA) is unclear. The main objective was to explore the differences in MVPA in children aged 8 to 10 years old having access or not to outdoor play structures during school recess time. A total of 82 children wore a wrist-worn heart rate monitor for seven consecutive days to determine time spent at MVPA using a Fitbit for a minimum of three full school days at various times of day and weekly. No difference in MVPA was observed when accessing or not the outdoor play structures within-group (n=37) median (25th - 75th) [(16 minutes (7-30) vs. 14 minutes (5-22) p=0.32)] nor between groups (n=22) [16 minutes (7-26) p=0.92)]. The strongest variable associated with MVPA during recess was weekly MVPA (p<0.01). Schools might want to have various options for children to play during recess, allowing children to cumulate MVPA.

Dedication

To my family, especially my mother, for her unconditional love and support.

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Chapter 1- Introduction

Physical inactivity is highly prevalent worldwide (World Health Organization, 2018) in all age groups, and it is related to health and fitness impairments that can lead to multiple diseases and chronic conditions, which later turn into poor quality of life, disability, and early mortality (Carson et al., 2017; Colley et al., 2019; Pradinuk et al., 2011). As a result, public health initiatives are needed to promote physical activity throughout all stages of life. Specifically for children, it is recommended to accumulate at least 60 minutes per day of moderate to vigorous physical activity (MVPA) involving various aerobic activities. In addition, vigorous physical activities and muscle and bone-strengthening activities should be incorporated at least three days per week to optimize the benefits of regular exercise (Tremblay et al., 2016). Many children do not meet the physical activity guideline worldwide (Cooper et al., 2015; Roman-Viñas et al., 2016). For example, only 52% of children in New Brunswick reach the recommended threshold of physical activity of 60 daily minutes of MVPA (PartiipACTION, 2020).

Sex and age of children impact their physical activity (Bogantes et al., 2018, 2020). During the transition to adolescence, sex differences in physical activity behavior appear; the amount of physical activity done by girls tends to decrease dramatically compared to that of boys, and the disparity persists into adulthood (U.S. Department of Health and Human Services, 2018). Besides age and sex, many factors influence physical activity in children. However, one vital factor is the level of physical activity during school activities because Canadian children spend at least 15% of their time per week at school during an academic year (Government of Canada, 2017). In most places around the world, during school time, children have opportunities to engage in physical activity, such as physical education and recess. Some national organizations from the United States recommend that schools offer daily physical education to K-12 children for at least 150 minutes per week (Michael et al., 2021). However, only 15% of schools offer physical education at least three times a week (Silva et al., 2018). With limited access to physical education classes during a typical week, recess represents an opportunity for children to help reach their daily physical activity recommendations by using play structures or engaging in free play.

Both play structures and free play contribute to physical activity in children. However, to date, only a few studies have objectively compared both settings to know if outdoor play structures are leading to more MVPA, contributing to the 60-min as recommended. Since the cost of play structures is exorbitant [($25,000 to $75,000 (Peterborough Public Health, 2017)], and it is not typically included in the initial budget when a school is built or renovated in most Canadian provinces, it is critical to know if play structures are associated with more time spent at moderate to vigorous intensity when compared with counterparts not having access to such structures.

The primary aim of this study was to explore the differences in MVPA in children aged 8 to 10 years old having access or not to outdoor play structures during recess time between children from the same school (n=41) and a different school (n=41). To put the study into context, we collected information about the playground size, parents' and children's demographics to characterize the sample, and the perceptions on the need for outdoor play structures for physical activity level in the context of elementary school ages. A total of 82 children wore a heart rate monitor (Fitbit Inspire 2) for seven consecutive days.

No difference was observed in MVPA during recess time within-group (n=37) median (25^{th} -75^{th}) [16 minutes (7-30) vs. 14 minutes (5-22) p=0.32)] nor between groups (n=22) 16 minutes [(7-26) p=0.92)]. The strongest variable associated with MVPA during recess was weekly MVPA (p<0.01). Based on this pilot work, schools might want various options for children to play during recess, allowing children to cumulate MVPA. Further research is needed to test strategies to increase MVPA during school recess.

Chapter 2- Literature Review

2.1 Benefits of Physical Activity

Physical activity is crucial in childhood to prevent non-communicable diseases at early ages (Chaput et al., 2020). There is also an association between physical activity and academic performance in childhood and adolescence (Prieto Benavides et al., 2015). In addition, being regularly active as a child increases the odds of being considered 'healthy' in adulthood (U.S. Department of Health and Human Services, 2018). Many benefits of physical activity are observed with an average of 60 minutes of moderate to vigorous intensity daily (Chaput et al., 2020).

Health benefits of physical activity include but are not limited to greater cardiorespiratory and muscular fitness, lower blood pressure, better lipid profile and glucose control, and lower insulin resistance. In addition, regular physical activity helps maintain a better cognitive function and is associated whit greater school performance, good memory, and executive function (Chaput et al., 2020; World Health Organization, 2020). Physical activity is beneficial in delaying or preventing metabolic and chronic diseases such as type 2 diabetes, cardiovascular diseases, and hypertension; it is also inversely correlated with the risk of obesity (Pradinuk et al., 2011). Cardiorespiratory fitness and physical activity share a bi-directional relationship (Colley et al., 2019). In addition, physical fitness is associated with health among children and youth, and low physical fitness has been linked to early mortality. Evidence shows that a higher duration of screen time is associated with lower fitness, poorer cardiometabolic health, shorter sleep duration, and unfavorable measures of adiposity (Chaput et al., 2020; World Health

Organization, 2020). Furthermore, greater adiposity (and other adverse health effects) may be most pronounced for those not engaging in high MVPA (Biddle et al., 2017).

Reducing sedentary time will increase opportunities to be active, translating to achieving physical activity and screen time recommendations (Colley et al., 2019). Finally, physical activity during childhood favors an increase in peak bone mass, which reduces the risk of osteoporosis and fractures throughout life (Alves & Alves, 2019).

Not only is physical activity associated with health outcomes, it is also related to economic outcomes. Ding et al. (2016) estimated the economic burden of physical inactivity. Their estimations showed that in 2013, physical inactivity cost the healthcare systems about $53.8 billion worldwide, of which $31.2 billion was paid by the public sector, $12.9 billion by the private sector, and $9.7 billion by households. In addition, physical inactivity-related deaths contribute to $13.7 billion in productivity losses, and physical inactivity was responsible for $13.4 million disability-adjusted life-years worldwide.

2.1.1 Factors influencing physical activity level

Much evidence suggests that the sex and age of children influence their daily physical activity level. Declines in physical activity begin at adolescence; young girls (6 to 11-year-old) engage in more moderate-intensity activities than older girls (12 to 17 years old), and boys engage in higher physical activity levels across age groups, with this difference being larger in older boys (Colley et al., 2017; U.S. Department of Health and Human Services, 2018). These differences are observed in many settings, such as school recess (Mitchell et al., 2016), curriculum time, and out-of-school (Button, Clark, et al., 2020).

Evidence on the physical activity level based on playground equipment is lacking. On the one hand, some evidence indicates that features and amenities may draw people to the playground, but once there, these features do not seem to influence their activity level (Colabianchi et al., 2011). On the other hand, other studies found a higher density of children in areas with fixed play structures and manufactured equipment and a lower density of children in densely vegetated or plain asphalted areas, and children in fixed areas were more likely to be very physically active than they were in other areas (Farley et al., 2008). For example, children who play in swing areas, play equipment areas, basketball areas, and tetherball areas have higher rates of MVPA than those who congregate in play fields or hard-surface areas (Anthamatten, Brink, et al., 2014). In addition, Pereira et al. (2020) found that playground dimension was a statistically significant predictor but was negatively related to children's MVPA.

Children's physical activity is also associated with seasons and weather. Moderate to vigorous physical activity is usually lower in autumn and winter compared with spring (Atkin et al., 2016). The same author reported that December had the lowest rate of moderate to vigorous intensity physical activities and June the highest (Atkin et al., 2016). More evidence indicates that MVPA levels increase as temperature increases; each extra degree increase in temperature is related to about 80 seconds of daily MVPA (Button, Clark, et al., 2020). Rain also significantly negatively influences children's daily physical activity levels; in contrast to rain, snow does not significantly influence total physical activity (Button, Clark, et al., 2020).

In contrast, Blanchette et al. (2021) observed that temperature in three Canadian regions was not associated with children's weekday physical activity. However, during the weekend, precipitation and lower temperatures affected children's physical activity. It is important to note that there were differences across regions, but their results suggest that weather variations influence children's physical activity to a greater extent than seasonal variations (Blanchette et al., 2021)

Besides seasonal variability, there is also a difference in the level of physical activity between week and weekend days (Atkin et al., 2016; Button, Clark, et al., 2020). A study by Uvacsen et al. (2011) showed that children spent significantly more time in sedentary activity on weekdays than on weekends. Researchers observed significant decreases in boys' and girls' MVPA of 32.8 minutes and 31.2 minutes, respectively, between weekdays and weekend days (Uvacsek et al., 2011).

2.2 Measurement of physical activity level

The most common methods to measure physical activity levels for children are heart rate monitoring, pedometry, accelerometry, and self-reports, all coming with advantages and disadvantages (see Table 1) (Biddle et al., 2011; Eckard et al., 2019; Epstein et al., 2001; Hollis et al., 2016; Massin et al., 2004; Ridgers et al., 2007a; Rowlands et al., 1997; Stratton, 1996).

Heart rate reserve is the difference between maximal and resting heart rate. It might be the most effective method of estimating heart rate thresholds appropriate for promoting health and fitness in school-age children as it accounts for individual resting values. (Stratton, 1996). Moderate-intensity physical activity refers to physical activity that is performed between 50% and 70% of heart rate reserve (HR max-resting HR X %intensity + resting HR) for children and youth (Chandler et al., 2015; Stratton, 1996). Moderate intensity can also be identified based on raw heart rate, such as a heart rate above 140 beats per minute (Eckard et al., 2019) or a percentage of maximum heart rate between 64 and 76% (American College of Sports Medicine, 2022).

Heart rate is considered a more sensitive measure than steps per minute to assess physical activity for assessing a wide range of activities (Eckard et al., 2019). Heart rate increases with exertion and is an indirect estimate of physical activity intensity, which assumes that a linear relationship exists between heart rate and oxygen uptake (Rowlands et al., 1997; Shei et al., 2022). Monitors collect heart rates at small intervals over prolonged observations and facilitate the measurement of the accumulation of short bouts of physical activity throughout the day (Epstein et al., 2001). Table 1 presents different methods to quantify physical activity in children, along with advantages, disadvantages, and the validity /reliability of each method.

Table 1. Methods to measure physical activity level among children

Method	Advantages	Disadvantages	Validity/Reliability
Chest strap Heart rate monitors (e.g., Polar)	Widely accepted criterion measure for heart rate (Brazendale et al., 2019). Affordable and user-friendly method to determine short-term heart rate variability outside the laboratory setting (Nunan et al., 2009).	RR intervals obtained during exercise induce noises on the measured electric signal (Cassirame et al., 2017) Wearability issues during long-term measurements as it requires the addition of an electro gel for conductance. (Kunkels et al., 2021; Spierer et al., 2015)	There is a close agreement between ECG and heart rate monitor measures of heart rate variability; a validity correlation coefficient of 0.99 reflects the standard error of the estimate findings and indicates near-perfect validity for measures of mean RR intervals (Nunan et al., 2009) Evidence suggests that calculating heart rate variability indexes using a series of RR intervals obtained by two different heart rate monitors is as reliable as those obtained by electrocardiogram (de Rezende Barbosa et al., 2016).

Wrist-worn heart rate monitor (e.g., Fitbit)	Provides adequate daily wear-time coverage since it can be used to capture 24-hour heart rate data for an extended period (Brazendale et al., 2019) Good adherence (Kunkels et al., 2021)	It tends to underestimate heart rate depending on activity intensity (Fuller et al., 2020). Accuracy decreases with increasing exercise intensity (Shei et al., 2022). Tracker better recognizes active minutes for physical activities that do not incorporate stepping. It is recommended to enter personal details (age, sex, weight) for better activity level tracking (Evenson et al., 2015).	In free-living settings examining healthy children, the measurement error falls within the acceptable limits of a percentage difference of ±10% (Fuller et al., 2020) Among healthy children, the correlation between Fitbit Charge HR (Heart Rate) and Polar HR is r=0.884, represented by an absolute difference of 8.9 bpm and an absolute percent difference of 6.9% (Brazendale et al., 2019).
Accelerometer (e.g., Actigraph)	Can collect data over a minimum of 5 days to a maximum of 1 year at the minimum epoch length	The device should be worn long enough (e.g., four days) to represent the measurement duration of interest accurately (Fiedler et al., 2021).	Test-retest reliability of two epoch lengths (10 and 60-s epochs) in children indicates that data of two measurement weeks represent comparable weeks of everyday life concerning physical activity. Also,

	(McClain & Tudor-Locke, 2009) Real-time data sampling allows for the measurement of physical activity patterns (Trost, 2001)	Insensitive to many forms of activity (Trost, 2001). The choice of epoch length alone can change estimations due to high intermittent physical activity patterns in children (Fiedler et al., 2021). It requires an instrument software to download the data, and the prices range from $200 to $400 (McClain & Tudor-Locke, 2009). Data collection is limited to battery life (McClain & Tudor-Locke, 2009).	there is a high and consistent validity in moderate and vigorous physical activity (Fiedler et al., 2021)

Pedometer	Simple and low-cost estimate of the total volume of physical activity outputted as the number of steps taken (McClain & Tudor-Locke, 2009). Piezoelectric pedometers are like most other accelerometers and have improved precision in step counting (McClain & Tudor-Locke, 2009, 2009). Distinguish between individuals who vary based on steps per day. (Schneider et al., 2004).	Do not detect time in specific intensity categories or provide information about the frequency, intensity, or duration of physical activity (McClain & Tudor-Locke, 2009; Trost, 2001). Not useful for activities not related to ambulation. Differs in costs, internal mechanisms, and sensitivity (Schneider et al., 2004). Step counts are influenced by body size and locomotion speed (Trost, 2001).	Evidence shows a correlation of 0.92 between steps recorded by pedometer and scaled oxygen consumption during treadmill walking/running and unstructured play activities in 8- to 10-y-old children, and a correlation greater than 0.95 directly observed physical activity in 12-year-old children (Trost, 2001). The accuracy of pedometers in counting steps ranged from ±3% to ±37% of the actual steps taken 95% of the time. Cronbach's alpha was >0.80 for nine out of ten pedometers. The intra-model reliability ranges from exceptionally high to poor accuracy, having 95% prediction intervals within ±17, ±100, and ±188 steps (of an average of 513) from zero, based on the model tested (Schneider et al., 2003).

Self-reports	Convenient in large samples (Fiedler et al., 2021).	Inconsistent results due to either over- or underreporting of physical activity and recall bias, it increases the burden of participants if multiple or frequent reports (Fiedler et al., 2021)	The correlation coefficient values for validity are 0.27 (95%CI: 0.23-0.31) for moderate to vigorous intensity physical activity. Combined values of intraclass correlation coefficients for reliability are 0.75 (95%CI: 0.68-0.83) for moderate to vigorous intensity physical activity (Yang et al., 2020).

Heart rate is used to estimate daily activity in children and utilized as a criterion to validate commercial accelerometers due to the linear relationship between heart rate and energy expenditure during steady-state exercise (Rowlands et al., 1997; Trost, 2001).

Electrocardiogram is the gold standard for heart rate monitoring (Nelson & Allen, 2019). Electrocardiogram allows continuous measurements with high accuracy for 24-48 hours (Kunkels et al., 2021). However, it is too costly and complex to be used in the field because it has limited data storage and battery capacity and requires trained personnel to operate effectively (Dooley et al., 2017; Kunkels et al., 2021; Laukkanen & Virtanen, 1998). To address these limitations, some activity trackers are now wearable and commonly designed to be worn on the wrist as a watch. Fitbit is one of the most popular commercial wearable activity trackers that allows recording heart rate using a non-invasive photoplethysmography technique (Feehan et al., 2018; Spierer et al., 2015). Photoplethysmography is an optical measurement technique that uses a light-emitting diode that shines directly into the skin and detects changes in the blood volume in the microvascular bed of tissue. Heart rate is determined based on the theory that blood flow is inversely proportional to the amount of light refracted (Feehan et al., 2018). Fuller et al. (2020) conducted a systematic review on wrist-wearable devices for measuring heart rate (mean age 29.8 years, SD 10.5 years with one study conducted with children age 8.2 years, SD 3.1 years) against the reference standard criterion measure of a Polar brand chest strap. They concluded these devices were valid, with a slight tendency toward underestimating heart rate (estimated median error: −1%). Group measurement error was reported, with the Fitbit Charge HR falling within ±10% measurement error in the study examining healthy children, which has been considered within the acceptable limits of percentage difference (Fuller et al., 2020).

There are limited data on Fitbit and its use with pediatric populations, but an example from the evidence is a study conducted by Pelizzo et al. (2018). They evaluated heart rate monitoring accuracy with a Fitbit Charge HR (Fitbit, San Francisco, CA, USA) in hospitalized pediatric patients undergoing elective surgery by comparing the accuracy of heart rate recordings with gold standard measurements obtained by continuous electrocardiographic monitoring. Among 30 children (16 boys, 14 girls, mean age 8.21 ± 3.09), heart rate values derived from Fitbit agreed with those recorded during an electrocardiogram (r=0.99; average bias of −0.05 bpm, 95% CI: 2.454–2.43 bpm). Findings showed that Fitbit-measured heart rate was accurate compared to HR measured during electrocardiography monitoring for children at rest and performing light activities (Pelizzo et al., 2018).

Another example of the validity of activity trackers in children comes from Brazendale et al. (2019); they examined the validity of wearable fitness trackers to capture heart rate in children when compared to a criterion measure: HR chest strap (Polar heart rate monitor H7). The correlation between Fitbit Charge HR and Polar H7 was r=0.84, represented by an absolute heart rate difference of 8.9 bpm and an absolute percent difference of 6.9%. A Bland-Altman plot showed that 75% of the heart rate estimates from the Fitbit device were within ±10% of the criterion measure, with 51% falling within <5%. BlandAltman plots indicated a moderate-to-high level of agreement between the Fitbit and polar heart monitor (mean difference of 4.1%; limits of agreement of 26.8, -18.5%).

Overall, there are many ways to quantify children's physical activity levels with valid wrist-worn activity trackers, which might lead to better adherence.(Eckard et al., 2019; Kunkels et al., 2021; Rowlands et al., 1997).

2.3 Physical activity recommendations for children aged 5-11

The Canadian 24-hour Movement Guidelines (2016) for children and youth indicates that children should sit less, have limited screen time, exercise at different intensities, and sleep a minimum of 9 to 11 hours (CSEP, 2016). Although all the elements of the 24-hour movement guidelines are associated with benefits, exercise seems to be the most significant predictor of health outcomes (Poitras et al., 2016). Children should accumulate at least 60 minutes daily of MVPA involving various aerobic activities for optimal health benefits. In addition, vigorous muscle and bone-strengthening activities should each be incorporated at least three days per week (CSEP, 2016).

Aerobic activities are movements in which people rhythmically move large muscles for a sustained time inducing cardiorespiratory adaptations; for example, brisk walking, running, hopping, skipping, jumping rope, swimming, dancing, and bicycling would be considered aerobic activities (U.S. Department of Health and Human Services, 2018). Muscle-strengthening activities make muscles work against a greater load than usual during daily activities. They can be structured, such as lifting weights, body weight, or working with resistance bands, or unstructured and part of play, such as playing on playground equipment or climbing trees (U.S. Department of Health and Human Services, 2018). Evidence suggests that strength training does not negatively influence children's linear growth and that vigorous physical activity limits adipose tissue growth but not linear growth in school children (Alves & Alves, 2019). On the other hand, bone-strengthening activities produce a force (commonly produced by impact to the ground) on bones promoting bone growth and strength (U.S. Department of Health and Human Services, 2018).

It is critical to provide young people with opportunities and encouragement to participate in physical activities that are appropriate for their age, enjoyable, and diverse (U.S. Department of Health and Human Services, 2018). As a result, many organizations have invested in organized sports and accessible outdoor play structures.

2.4 Physical activity level among children

Quantifying the level of physical activity for children is challenging, but some networks are collaborating to collect data on the subject. One example is the International Children's Accelerometry Database consisting of ActiGraph accelerometer data in ten countries from children aged 3 to 18. Data from this database (Cooper et al., 2015) showed the following findings: researchers observed consistent associations between demographic characteristics and physical activity levels in all countries; physical activity varied between countries, with a 15–20% difference between the highest and lowest countries at age 9–10 and greater differences at age 12–13; finally, physical activity did not differ by weight status in the youngest children, but from age seven onwards, overweight/obese participants were less active than their normal weight counterparts.

Another important international epidemiological study is the International Study of Childhood Obesity, Lifestyle and the Environment study involving 12 countries. This study aims to determine relationships between lifestyle behaviors and obesity in Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, the United Kingdom, and the United States. The average time spent at MVPA is 60 min/per day ranging from 45 min/per day in China to 72 min/per day in Kenya (Roman-Viñas et al., 2016). Canada was close to the average with 58 minutes per day, with 42.6% meeting the MVPA recommendation.

Specifically in Canada, one of the primary data resources is the Canadian Health Measures Survey. This survey is completed every two years and collects notable health information through a household interview and direct physical measures (i.e., accelerometer) at a mobile examination center (Government of Canada, 2018). Results from the fifth cycle of the Canadian Health Measures Survey (2016 and 2017) reported that average children aged 5 to 11 years old achieved 65 min/day of MVPA. However, only 47% of children aged 5 to 11 achieved 60 minutes of MVPA daily as recommended (Government of Canada, 2019).

Borghese & Janssen (2019) conducted a study with 337 children from Kingston, Ontario; they estimated time spent in four types of physical activity (active outdoor play, active travel, curriculum-based physical activity, and organized sport) and the intensity of these activities. They found that daily moderate to vigorous intensity was ≥60 min/day in 36% of participants, moderate to vigorous movement intensity was higher for boys than for girls, highest for children participating in spring organized sports, and lowest for children participating in the summer organized sports (Borghese & Janssen, 2019). Children in the study spent more time participating in organized sports (40 min/day) and active outdoor play (36 min/day) than they did participating in active travel (17 min/day) and curriculum-based physical activity (26 min/day) (Borghese & Janssen, 2019).

In New Brunswick, only 32% of children in New Brunswick meet the recommended 60 minutes of MVPA. Among children aged 5 to 10 years, only 52% achieve the threshold of 60 minutes of daily MVPA (ParticipACTION, 2020).

2.5 Physical Activity in Schools

In Canada, children and youth spend approximately seven hours per day at school from September to June (ParticipACTION, 2020). Schools are uniquely positioned to positively influence physical activity levels as they reach most children and youth, regardless of gender, race, ethnicity, or family circumstance (ParticipACTION, 2020). Moreover, physical education is a regular period for children to engage in health-enhancing physical activity. Although the frequency of elementary grade physical education differs worldwide, when combined with other opportunities with family, and community-based physical activities, this physical activity as part of the curriculum can make a meaningful contribution to children's physical activity levels (Fairclough & Stratton, 2006).

The 2015 Opportunities for Physical Activity at School Survey reported that most schools (60%) implemented supportive policies to support physical activity in schools (Canadian Fitness and Lifestyle Research Institute, 2016). School administrators also reported that several amenities are available on-site at school, including equipment for physical activity (97%), gymnasiums (94%), playing fields (88%), other green spaces or play areas (88%), paved areas used for active games (80%), outdoor basketball hoops (78%) and areas with playground equipment (71%).

The International Study of Childhood Obesity, Lifestyle, and the Environment (Silva et al., 2018) indicated that 24.8% of children aged 9 to 11 self-reported participation frequency in physical education classes three or more times per week. Among high-income countries (Canada, Finland, the UK, the United States, Australia, and Portugal), Canada had the most students reporting attending physical education classes for three days or more in the week (64.8%), as opposed to low to middle-income countries (Brazil, China, Colombia, India, Kenya, and South Africa), where most of the children only have access to physical education 1-2 times a week.

Considering the high level of obesity and its associated health impacts, parents, educators, and health researchers strive to find which environmental interventions could encourage physical activity among children (Anthamatten et al., 2011) and the school provides an inclusive and structured environment (Vander Ploeg et al., 2012). Effective school-based interventions include some combination of school curriculum, printed educational materials, educational sessions, physical activity-specific sessions, and community-based initiatives (Dobbins et al., 2013). There is some evidence to suggest that school-based physical activity interventions may have a positive effect on increasing the proportion of children who engage in MVPA during school hours; these positive effects are maintained in the longer term (i.e., six months to four years) (Dobbins et al., 2013). Yuksel et al. (2020) analyzed 19 school-based physical activity interventions on obesity, physical activity level, and fitness in children. Their results indicate improvements in all outcomes and emphasize the need to develop the children's motor skills to be active throughout their lives (Yuksel et al., 2020). School-based interventions focused on promoting physical activity through physical education curriculum, changes to the school curriculum, and changes in school routines to increase students' physical activity time. The goal is to increase students' time in MVPA during school days using various strategies (Dobbins et al., 2013; Yuksel et al., 2020).

A way to know if an intervention helps increase physical activity meaningfully is using the minimal clinically important difference; however, evidence from the literature is limited. Graham et al. (2022) calculated the minimal clinically important difference in the time spent at MVPA in children. They based their calculations on the daily change in MVPA levels for each childhood year; they calculated that participation in MVPA decreases on average by 3.6 ±0.5 min per day. Therefore, the minimal clinically important difference is 3.6 min per day (intervention minus control, over each year), as any increase in MVPA above this amount could be considered as reversing the current decline in MVPA levels that occurs throughout childhood (Graham, Azevedo, et al., 2022).

2.5.1 Recess and Play

School recess provides space for children's physical, social, and emotional development, essential for well-being and learning (Ramstetter et al., 2021). Recess is defined as blocks of unstructured time during the school day, typically outdoors, that allow children to participate in regular physical activity as they freely choose activities and playmates (Burriss & Burriss, 2011). Some factors contribute to the physical activity level of children during recess, such as the lack of facilities, lack of available space to play, sports equipment, school policies restricting movements for security reasons, lack of policies at the school level, and the lack of support (Bogantes et al., 2018).

Recess is a crucial time that children can rely on to freely discover, undertake play challenges, explore their senses, and make independent play decisions away from the confines of classroom walls, restrictive rules, routines, and regulations (Ramstetter et al., 2021). According to Babkes et al., (2014), the most popular activities among children from 3rd to 5th grades for boys are running, kicking, and throwing, whereas for girls, are running, talking, swinging, jumping, and monkey bars. Recess contributes 17.9% and 15.5% of boys' and girls' physical activity levels during a school day, respectively (Ridgers et al., 2011).

2.5.2 Free play

Free play constitutes a critical element of a healthy lifestyle for children. Free play is defined as gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner often done outside (Truelove et al., 2017). There are diverse types of play, including free-style play (fantasy role-play), build-it play (e.g., building a sandcastle), mirror-me play (e.g., children mimicking adult behavior), and muddy boots play (e.g., hide-and-seek) (ParticipACTION, 2020). Evidence suggests that outdoor play in minimally structured, free, and accessible environments facilitates socialization with peers, the community, and the environment, reduces feelings of isolation, builds interpersonal skills, and facilitates healthy development. In addition, children are more curious about natural spaces than prefabricated play structures; furthermore, children who engage in active outdoor play in natural environments demonstrate resilience, self-regulation and develop skills for dealing with stress later in life (Tremblay et al., 2015).

Larouche et al. (2019) analyzed the relationship between outdoor time and physical activity level in a large sample of children from study sites within 12 different countries. They found that using the United States as the reference group, boys and girls in Canada, China, Colombia, and Portugal had significantly lower outdoor time, with girls spending 16.5 fewer minutes per day outdoors (Larouche et al., 2019).

Overprotecting parents limit physical activity during free play (ParticipACTION, 2020). Veitch et al. (2006) interviewed 78 parents from five primary schools representing a range of metropolitan and outer-urban Melbourne socioeconomic status areas. They found that some of the major issues that parents considered to have the most impact on their child’s active free-play include: safety concerns, the child’s level of independence, social aspects, attitudes to active free-play, facilities at parks/playgrounds, and environmental/urban design (Veitch et al., 2006).

To ensure high quality through body multi-sensory experience and safe outdoor play experiences, outdoor spaces should be built purposefully and considering the following recommendations (Berg, 2015; Olsen & Smith, 2017; ParticipACTION, 2020):

- Promote and support outdoor and, when possible, nature-based play opportunities given their association with increased physical activity levels and improved mental health outcomes;

- Nurture frequent active play opportunities; given that children learn through play, this will support children's development and keep them healthy.

Moreover, educators should allow time for inclusive child-centred outdoor play exploration and prioritize outside time. They can provide children with the following: play materials, toys, and loose parts to encourage physical movement; environments that support emotional, social, and intellectual development; environments that follow health and safety standards and guidelines; and open play space.

From a public health perspective, active play may be easier to promote among young children than structured physical activity, emphasizing having fun while moving around without the need for structured programming or specific equipment (Truelove et al., 2017). Overall, not having outdoor play structures does not necessarily mean a negative impact on the level of physical activity among children since free outdoor play still constitutes a solid opportunity to be active.

2.5.3 Playgrounds

A school playground is the school's outdoor area for children to use during recess. School playgrounds can encompass grass and tarmacadam areas and may contain playground markings and equipment for children to use (Ridgers et al., 2006). Traditional playgrounds restrict children's play to steel equipment and solid surface areas and encourage play for children below 12 (Burriss & Burriss, 2011; Peterborough Public Health, 2017). A traditional model includes play structures such as slides, monkey bars, and sandbox either stand-alone or as a composite structure in bright primary colours in an open space under the glare of the sun (Peterborough Public Health, 2017). This model continues to be the staple of outdoor play spaces for children; however, children deserve to have outdoor play environments that are designed with the intention of them learning, discovering, and enjoying (Olsen & Smith, 2017).

Features on school playgrounds can be classified as vertical features (manufactured features) and horizontal features (markings and surfaces designed for activity) (Anthamatten, Fiene, et al., 2014). Loose equipment is also important; it is defined as parts with no defined purpose that can be used in many ways to play (Frost et al., 2018; Ickes et al., 2013; Olsen & Smith, 2017). It is still debated whether outdoor play structures are necessary to optimize the physical activity level during recess, but many interventions have been tested because of the cost. It is important to mention that evidence on the effect of play equipment and outdoor structures in the school playground on children's physical activity and playground behavior is still lacking (Ridgers et al., 2006). Powell et al. (2016) found that children can be active in a poorly resourced environment. Their study showed that children spent 64% of their time in MVPA when engaging in locomotive activity.

Markings are a popular strategy to increase the physical activity level among children during recess at a lower cost than outdoor play structures (Baquet et al., 2018; Blaes et al., 2013; Cardon et al., 2009; Ridgers et al., 2007b). Blaes et al. (2013) conducted a study with children aged 6 to 11 years in elementary schools, creating a playground marked with thermoplastic girdles (which cost 15,000 euros per school); the intervention caused a statistically significant increase in time spent at moderate to vigorous intensity in comparison with baseline. Another study demonstrated that a school-based playground markings intervention could increase the time spent in MVPA over time; children who benefit from playground markings engage in up to 3.4% more MVPA than those who do not have playground markings (Baquet et al., 2018). Other studies did not show remarkable results. For example, Escalante et al. (2014) found that interventions based on playground markings, game equipment, or combining the two did not increase the physical activity of preschoolers and school children during recess.

A zoned playground by activity is another simple and effective strategy to increase physical activity during recess (Barnas et al., 2018). Zoned playgrounds are designed to provide freedom of choice and involve dividing the existing recess area into distinct zones, each with a specific associated activity and additional equipment when necessary (Barnas et al., 2018). Ridger et al. (2007b) conducted a study where fifteen schools received £20,000 to redesign their playground environment based on the sporting playground zonal design, which uses three colour-coded areas involving different activities. Data were collected at baseline, after six weeks, and again after six months following the redesigns of the intervention schools' playgrounds. They measured physical activity levels using a heart rate monitor and calculating heart rate reserve; they found that intervention school children engaged in 4% and 2.4% more MVPA and vigorous physical activity, respectively, during recess than control school children and that the intervention effect was stronger with increasing recess duration and for less active children (Ridgers et al., 2007b). This is important as recess interventions could promote physical activity as children spend time outdoors on the playground; they increase their access to facilities and may decrease their perceived barriers to activity engagement as a few activities were offered in the specific zones within well-resourced playgrounds (Ridgers et al., 2007b).

2.5.3.1 Outdoor structures

A play structure or structural equipment has been built and designed with a predetermined purpose in the playground (Frost et al., 2018). The typical outdoor play structure is open and flexible, creating a situation easy to influence for the individual child and promoting play sequences in which rapid sequences easily alternate with calmer sequences of more intimate interaction with place and peers. (Mårtensson et al., 2009)

Manufactured prefabricated composite play structures are costly (e.g., $25,000 to $75,000) (Peterborough Public Health, 2017). In New Brunswick and most Canadian provinces, acquisition, and installation of play area equipment and protective surfacing by outside groups is subject to District Education Council policy and may only proceed under the school district's supervision. Funding is a one-time allocation to a maximum of $10,000 per school (Government of New Brunswick, 2003). Given the evident difference between funding and actual cost, it is crucial to investigate whether children use outdoor play structures and whether they are associated with benefits such as greater physical activity during or after school hours.

Some studies suggest that a higher density of play features and constructed equipment positively affect physical activity. Children tend to congregate in areas with fixed play equipment, and when they are in those areas, they are more likely to be more physically active (Anthamatten et al., 2011; Colabianchi et al., 2011; Farley et al., 2008). Evidence shows a positive association between playground area per child and beforeschool vigorous physical activity, suggesting that larger playground areas may facilitate more vigorous play (Ridgers et al., 2010). Similarly, Fairclough et al. (2012) determined that moderate physical activity during lunchtime positively correlates with playground area per student. Bohn-Goldbaum et al. (2013) found that parents' main reason for visiting playgrounds is to let children play because of the available equipment and proximity. Also, it is important to consider that parents most often encourage physical activity through structure and emotional support (Tu et al., 2017).

Table 2 summarizes the advantages and disadvantages of outdoor play structures.

Table 2. Advantages and disadvantages of outdoor play structures

Advantages	Disadvantages
Attractive to children and increase the likelihood of being active. Facilitate more vigorous play. Allow the introduction of loose equipment or markings.	Acquisition and maintenance are costly. Not designed for all age groups. Associated with injuries and risk of falls. Supervision and inspections are recommended. Encourage only a few particular types of activities.

Overall, play structure designs should be appropriate for age, and since children can use equipment in unintended and unanticipated ways, adult supervision is highly recommended (U.S. Consumer Product Safety Commission's, 2015). In addition, risky play is positively associated with fixed equipment for functional play, nature, and other fixed structures (Sandseter et al., 2021). Using outdoor play structures is associated with injuries. As of 2009, in Canada, approximately 2,500 children aged 14 and under were hospitalized annually because of playground falls (play at height), and 81% were for fractures. In New Brunswick, falls from playgrounds were the fourth cause of hospitalization among this age group (Atlantic Collaborative on Injury Prevention, 2009)

To maximize physical activity during recess and school day, it is crucial to determine students' intensity, type of activity, and places where children play, to design interventions and recommendations focusing on these variables (Bogantes et al., 2020).

2.6 Gap in literature

Current evidence on the role of outdoor play structures on the physical activity level at moderate to vigorous intensity is unclear. On the one hand, some studies comparing different playground interventions suggest that outdoor play structures attract more children and help them to be more active; conversely, other studies show that free play can lead to similar time spent at moderate to vigorous intensity. In addition, outdoor play structures are expensive and can increase the risk of injuries.

When a new public school opens, it offers a timely opportunity to test if the presence of outdoor structures is associated with more time spent at moderate to vigorous intensity. This study filled this gap in the literature by answering the following question: Do children achieve different levels of physical activity during an entire week at school regardless of whether or not they have access to play structures during recess?

2.7 Objectives and Hypothesis

The primary purpose of this pilot study was to explore the differences in minutes of MVPA between children who have or do not have access to outdoor play structures during recess and explore the potential factors influencing their level of physical activity at moderate to vigorous intensity during school recess time.

Secondary outcomes included the number of minutes children spent at moderate to vigorous intensity at other times during the week and exploring the variables associated with MVPA during school recess.

This study hypothesizes that minutes of moderate to vigorous activity among children aged 8-10 will not be different when they access or do not to outdoor play structures during recess time. We also hypothesized that children's sex and age, total weekly MVPA and parent's leisure time score would be associated with weekly time spent at moderate to vigorous intensity among children.

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Chapter 3-Article

Outdoor play structures and moderate to vigorous physical activity for children aged 8-10 years old during recess: A pilot study

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Authors' contributions

Diaz MF participated in the study design, acquisition, analysis, and interpretation of data and drafted the article.

Short title: MVPA among children during recess.

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Abstract

Background: Recess is an opportunity for children to engage in activities to reach moderate to vigorous physical activity (MVPA), contributing to meeting the aerobic physical activity guidelines. This study explored the differences in MVPA when children have access or not to outdoor play structures during recess.

Methods: A natural experiment of 41 children aged between 8 and 10 years old having access to playground structures during the afternoon recess but not in the morning for an entire week in October 2022. To control the temperature difference, the same number of participants from another school not having access to playground structures during the afternoon were invited to participate. Moderate to vigorous physical activity (>50% of heart rate reserve) was determined using heart rate (Fitbit, Inspire 2, San Francisco, USA) for a minimum of three full school days at various times of day and weekly.

Results: Out of 100 minutes of recess analyzed over the school week, no difference in MVPA was observed when accessing or not the outdoor play structures within-group (n=37) median (25^{th} -75^{th}) [(16 min (7-30) vs. 14 min (5-22)] nor between groups (n=22) [16 min (7-26)]. Weekly MVPA among all participants (n=59); 172 min (117-282) was the strongest variable associated with MVPA during recess t(df)=5.40 (38), 95% CI 0.04-0.09, p<0.001].

Conclusion: Accessibility to outdoor play structures does not increase MVPA during school recess for children ages 8 to 10. Based on this pilot work, schools might want various options for children to play during recess, allowing children to cumulate MVPA. Further research is needed to test strategies to increase MVPA during school recess.

Keywords: Heart rate, measurement, recess.

1. Introduction

Children aged 5 to 11 should accumulate at least 60 minutes per day of moderate to vigorous physical activity (MVPA) for optimal health benefits.[1] However, about a third of children meet the physical activity recommendations globally.[2] The main factors affecting physical activity level among children are age and sex,[3] but temperature and precipitation also influence the physical activity level when activities are performed outdoors.[4,5]

Schools are uniquely positioned to positively influence physical activity levels as they reach most children and youth, regardless of gender, race, ethnicity, or family circumstance.[6] Additionally, time spent at school, specifically during recess, provides children with the opportunity and space for physical, social, and emotional development.[7,8] Physical activity level during recess is influenced by factors such as equipment availability, facilities, and space, policies at school, or support.[9] During recess, children can engage in free play or use play structures. Free play is a critical element of a healthy lifestyle for children,[10,] and it is usually performed outdoors where children exert energy in a freely chosen, fun, and unstructured manner.[11] On the other hand, play structures are built and designed to offer opportunities for children to have predetermined sequences of play.[12,13] Although attractive, play structures are costly, and for many, no budget is planned for these when a school is built.[14] Additionally, play structures increase the risk of injuries and offer limited activities.[15,16]

Some evidence points out that not having outdoor play structures does not necessarily negatively impact children's physical activity level since free outdoor play still constitutes a solid opportunity to be active.[10,11] Although no study has rigorously compared access vs. no access to play structures, some evidence might suggest no advantage of play structures. One study tested playground vs. open space (n=25) with children aged 8-9 and reported an advantage to free play in the open space.[17] This study reported that 61.6% of the variance in MVPA was due to the playing environment. Participants engaged in 40% more MVPA when playing on the field compared to the playground. One of the main limitations was that they did not describe if outdoor play structures were present in the playground; in addition, they used accelerometers to measure physical activity only during the final two days of each week, which might not be fully representative of overall weekly activity and the novelty of having the accelerometer attached to the participant's hip could have introduced some bias towards normal children's behavior.[17] In the present study, outdoor play structures were part of the comparison, and watches were used to record heart rate and measure physical activity intensity. Watches were selected so children felt more comfortable wearing them without introducing bias and favoring adherence to their use.[18] Data collection lasted seven days, and particularly, MVPA during recess was monitored for five school days to better represent the whole week. All this might address the limitations of the previous study and help add new findings.

The primary purpose of this pilot study was to explore the differences in time of MVPA between children who have or do not have access to outdoor play structures during recess and explore the potential factors influencing their level of physical activity at moderate to vigorous intensity during school recess time. The secondary outcomes were minutes of MVPA during other times of the week and variables associated with MVPA during school recess.

2. Methods

2.1. Study Design

This pilot study was a natural experiment, as the exposure to play structures was outside of the control of the research team, and it was determined by existent resources in the participant schools. Throughout this study, the influence of outdoor play structures on MVPA (reported as weekly minutes) was explored in children during recess.

2.2. Ethical approval

This project was approved by the Research Ethics Board of the University of New Brunswick and is on file as REB 2022-104.

2.3. Setting

Approval was obtained from the Department of Education and school districts. Principals were recruited and after agreeing to be part of the study, instructions were sent to them in

September 2022 to coordinate the project on-site (Appendix A). Parents and staff were informed of the study by the principal of each school in September 2022. After this announcement, parents received an envelope containing all the information, forms, and questionnaires. To be in the study, the consent and assent forms had to be returned to the teacher and researchers.

Two schools participated in the study. Participants from the first school had no access to play structures in the morning recess but access to them in the afternoon recess. Since it has been reported in the literature that temperature might affect physical activity when it is performed outdoors, another school was recruited to allow data collection at the same time of the day. Participants from the second school had no access to play structures during both recess times. Since the duration of recess was different in the morning and afternoon, only the first 20 minutes of each recess time were analyzed.

2.4. Participants

Based on available resources and to have data collected during the same period at both schools, 82 children from the two schools were invited to wear a Fitbit (Inspire 2, San Francisco, USA) for seven consecutive days. The inclusion criteria were to be aged 8 to 10 years, receiving signed consent from their parents and signed assent from the children. Exclusion criteria included children whose parents reported being under heart, asthma, or blood pressure medication.

2.5. Data collection

2.5.1. Demographic information. Prior to the observation week, parents were asked to answer a questionnaire with their children's information: age, sex, grade, and if the child was registered in organized sports during the academic year, as well as their own sex, age, education level, income, and employment. Parents also reported their physical activity via the Godin-Shepard Leisure-Time Physical Activity Questionnaire,[19] and weekly resistance training frequency. Those who reported a leisure score index ≥ 24 were classified as active.[19]

2.5.2. Moderate to vigorous physical activity. Children from both schools wore the Fitbit on their non-dominant wrist, 24 hours a day, during the same seven days (Friday to Thursday) between October 21 and October 27, 2022. Time spent at moderate to vigorous intensity was measured via a wrist-worn heart rate using Fitbit (Inspire 2, San Francisco, USA). Moderate to vigorous physical activity was defined as an activity performed at a minimum of 50% of the heart rate reserve. The following formula was used to estimate the minimum heart rate to be considered at moderate intensity:[20]

$$(200 - resting\ heart\ rate)\ * 0.5\ +\ resting\ heart\ rate$$

Heart rate reserve was chosen because it effectively estimates heart rate thresholds appropriate for promoting health and fitness in school-age children as it accounts for individual resting values.[21] The maximum heart rate was estimated to be 200 for all participants.[22] Resting heart rate was determined as the lowest record of each day during the sleeping time (10:00 pm to 7:00 am). When sleeping time was unavailable, resting heart rate was determined by the lowest record of the day during waking time. Fitbit Intraday Heart Rate Service and a Phyton code were used to extract data (Appendix B). Only children who provided complete data during school time for at least three days were included in the analysis.[23,24] Missing information was replaced with the average of the recorded valid days. Data were analyzed following three steps. First, the average heart rate for each minute recorded and wearing time during the school day was estimated. Then, heart rate records above 50% of the heart rate reserve were converted to minutes of MVPA per day. Records were taken during the daytime (7 am to 10 pm), school time, and recess times following the school schedule provided by principals. Finally, the results from each day were summed up to estimate the total weekly minutes of MVPA for: 1) Week: seven consecutive days; 2) Weekdays: Monday to Friday; 3) Weekend: Saturday and Sunday; 4) School time (Monday-Friday) based on the schedule provided by school principals.

2.5.3. Weather conditions. The following information was collected from Environment Canada's weather website (https://weather.gc.ca/canada_e.html) to understand the context in which data were collected: temperature (T°), precipitation (mm), and relative humidity

(%). The mean temperature, precipitation, and relative humidity were recorded during the same seven consecutive days when children wore Fitbits. The weekly average of each weather condition was calculated.

2.5.4. Dimension of play space. Dimensions of the playground area for each school were measured on-site using a measuring wheel (m). After that, the available play space per child on the playground (m^2) was obtained by dividing the available playground area for each school by the number of children at the school reported by school principals.

2.6. Data analysis

Three analyses were performed: 1) within-group: school 1 (n=37), non-access vs. access, different time of the day, 2) between-group: school one access (n=37) vs. school 2 non-access (n=22), same time of the day to control for temperature differences; and 3) between-group: school 1 access (n=22) vs. school 2 non-access (n=22), matched by children's age and sex. The significance level was set at 0.05, and all analyses were performed using SPSS version 28 (IBM SPSS, US).

Demographic characteristics of participants and weather were reported as the median and interquartile ranges or frequencies and percentages. This approach was selected given the small sample size. A Kolmogorov-Smirnov test determined that the primary outcome residuals were not normally distributed. A Wilcoxon Signed-Rank test was computed for the within-group analysis to compare time spent at moderate to vigorous intensity when accessing outdoor play structures (n=37); a Mann-Whitney U test was used to analyze the difference between groups (n=59). A quantile regression analysis of factors potentially associated with time spent at moderate to vigorous intensity among children during recess was performed for between-group analysis, adjusting for children's age, sex, weekly time of MVPA (excluding recess time), and parents' physical activity level.

3. Results

A total of 41 children and their parents from each school were recruited, but only n=37 from school 1 and n=22 from school 2 had valid data related to the primary outcome. The average temperature during the five school days when data were collected was 11.5 ± 4.3

°C and 14.8 ± 2.7 °C during morning and afternoon recess times, respectively. The average precipitation was 7.9 ± 10.4 mm, but it happened after school, not affecting the primary outcome. Finally, the average relative humidity was 79.8 ± 1.7%. On average, children from School 1 had 15 m^2 and 13 m^2 of space to play in morning and afternoon recess, respectively. In contrast, children from School 2 had 25 m^2 of space to play during recess.

Table 1 shows the demographic characteristics of children having valid data from the heart rate monitor and their parents. Children's median age was eight, with 53% of girls and 62% attending sports during the academic year. The reporting parents were mainly women (70%). Parents of children from School 2 were older than those from School 1, but no significant differences existed in their income, education level, or employment.

Figure 1 shows the weekly minutes of MVPA during recess. Out of 100 minutes analyzed over the school week (five days for 20 minutes each recess), no difference in MVPA was observed when accessing or not the outdoor play structures within-group (n=37) median (25^{th} -75^{th}) [(16 minutes (7-30) vs. 14 minutes (5-22)] nor between groups (n=22) [16 minutes (7-26)].

Table 2 displays the minutes spent at moderate to vigorous intensity during different weekdays and recess times. No significant difference was observed between the groups. For example, children in School 1 (having access to outdoor play structures) spent 173 (104-266) minutes at moderate to vigorous intensity vs. 171 (130-298) minutes for children in School 2. Most children (81%) in the sample did not meet the weekly physical activity guidelines of 60 minutes at moderate to vigorous intensity per day.

Quantile regression (n=59) revealed that access to play structures does not predict the median number of minutes spent at MVPA during recess, nor children's age or sex, and parent's physical activity level. However, total weekly minutes (seven days without the recess MVPA) of physical activity was strongly associated with the level of activity during recess time [t(df)=5.40 (38), 95% CI 0.04-0.09, $p<0.001$].

4. Discussion

This pilot study aimed to explore the differences in time spent at moderate to vigorous intensity between children who have or do not have access to outdoor play structures during recess and to explore the number of minutes that children spent at MVPA at other times during the week, as well as the variables associated with spending more time at moderate to vigorous intensity during school recess.

Inverse to what was observed in the current study, a previous study reported 40% more moderate to vigorous intensity when children (age 8.6 ±0.3) were involved in free play compared to a playground.[17] However, what they call a playground consisted of concrete areas surrounded by school buildings while trees and bushes surrounded the free play area. This speaks about how comparing studies is complex as the fields and structures vary from one school to another and probably even more between countries. Nonetheless, another study has shown that children tend to be more active if the area includes grass,[25,] which is not the case in the studied schools. Finally, another study also found that physical playground features were not associated with physical activity at any intensity when evaluating 128 children aged 9-10 years old from eight schools.[26] The literature support why there is no difference in MVPA. One reason children in our study did not achieve more moderate to vigorous activity when accessing the outdoor play structures could be that the available space available was similar. One study reported that children are more active in spacious environments independently of structures,[27] and another suggested that children can be active in a poorly resourced environment as they can engage in locomotive activities associated with moderate to vigorous intensity.[28] These findings suggest that the presence of play structures alone might not determine the intensity of physical activity among children during recess.

Given the main results of this study, it is worth asking why to invest in outdoor play structures in schools. Play structures are unnecessary if the goal is to increase MVPA. However, a proper design and sample size are needed to confirm these observations. Not having access to playground structures during school recess could have advantages. For example, falls from playground equipment are the most prominent single hazard pattern associated with playground use,[16] with an annual average of 5,222 hospital stays in the US[29] and related health care costs estimated to be $106 million in Canada.[30] Also, most school staff perceived a lack of staff resources to supervise children using the playground structures children.[31] Another argument for prioritizing recess settings without playground structures is that the cost is usually not publicly funded.[15] On the other hand, outdoor play structures might offer other perceived benefits unrelated to physical activity level. For example, school staff has reported that play structures have extrinsic values of peer relationships and social development for children.[31] Another study conducted with 9-12-year-old children described that playgrounds support children's autonomy, competence, and relatedness that might not be observed in a free play setting.[32]

Children in the current study were relatively inactive, with only 18.5% meeting the weekly recommendation. It is hard to observe a difference between the two settings if none of the settings increases time spent at moderate to vigorous intensity during recess. Participants in moderate to vigorous intensity during approximately 17% and 18% of recess time when having access or not to play structures, which is below the percentage reported by Wood et al.[17] Maybe the low physical activity level observed in our study sample is a COVID effect that could be attributed to behavioral patterns adopted during the pandemic that persist even without pandemic restrictions. For example, Burkart et al. reported that from 2018 to 2019 children decreased MVPA by 8 min, but, for the next year, they had a decrease of 16 minutes.[33] In addition to these findings, Yelizarova et al. reported that in 2020, 47.0% of boys and 33.4% of girls of school age reached the recommended MVPA, compared with 35.3% and 17.9%, respectively, in 2021.[34] Despite a low proportion of the sample meeting the physical activity guidelines, our results suggest that children's activity level during recess is associated with overall physical activity. This suggests that every opportunity during the day is important to contribute to children's overall movement.

This study and the literature on the subject raise the question of what the purpose of recess is. According to Ramstetter et al., recess is a crucial time that children can rely on to freely discover, undertake play challenges, explore their senses, and make independent play decisions away from the confines of classroom walls, restrictive rules, routines, and regulations[8]. This implies that recess should be used as a time away from curricular activities. However, other authors, such as Burris & Burris suggest that recess is an excellent opportunity to contribute to children's overall movement.[7] Based on our findings, this contribution is currently very low. Given the association between total and recess moderate to vigorous activity, it is crucial to promote strategies to increase physical activity during recess, such as markings, zoned playgrounds, the addition of loose equipment, planned activities, staff involvement, and incorporation of grassed areas and green spaces.[35,36]

Additional strategies should aim to increase physical literacy, as evidence showed that children who met the Canadian physical activity guideline of 60 minutes of daily MVPA displayed higher physical competence, motivation, and confidence in physical literacy domain scores.[37] It is possible that children would spend more time at moderate to vigorous intensity during recess when accessing play structures if they were more physically literate. Another strategy is to increase outdoor time in children, as each additional hour per day spent outdoors has been associated with extra seven minutes of MVPA.[38]

4.1 Limitations/Future Studies

One of this study's strengths is using heart rate reserve to estimate physical activity intensity. Another strength is the three different analyses made within and between groups, naturally adjusting for differences in the setting and the temperature. However, we acknowledge several limitations, starting with the small sample size that prevents the generalization of the results to larger populations. Second, data were collected for only two 20-minute recess times during a week in the fall, which might not fully represent all-year activity. Third, it is possible that even if children had access to play structures, they might not have used them.

Future studies could address this limitation by conducting observational studies in addition to an objective measure of physical activity. Observational approaches could also provide a clearer description of the play structures' characteristics and how children use them given the high variability of play structures, and space dimensions from school to school. Additionally, future studies should include a more detailed description of the proportion of schoolyard space dedicated to play structures vs. open space. Finally, the current study focused on MVPA, but different intensities and types of activities would be worth to be explored, as play structures could offer other benefits that fall outside of the purpose of this study.

5. Conclusion

Accessibility to outdoor play structures does not increase MVPA during school recess for children ages 8 to 10. Our findings question the need for outdoor play structures to increase MVPA during school recess. Strategies should include various options that allow children to play freely and still accumulate MVPA. Further research is needed to test strategies to increase MVPA during school recess.

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Table 1. Demographic characteristics of participants

	School 1 (n=37) Non-Access: Morning Access: Afternoon	School 2 (n=22) Non-access both times
Children		
Age (years)	8 (8-9)	8 (8-9)
Sex (male)	17 (46)	11 (50)
Registered sports during the academic year (yes)	24 (65)	13 (59)
Parents		
Age (years)	40 (38-44)	37 (33- 39)
Sex (male)	13 (31)	5 (23)
Total household income (≥$80,000)	20 (54)	14 (63)
Marital status (married)	31 (86)	22 (100)
Education (college or above)	35 (94)	14 (63)
Employment (full-time)	32 (62)	17 (77)
Leisure Time Score (≥24: active)*	35 (15-48)	37 (23-56)
Resistant training (times per week)	0 (0-2)	2 (0-4)

Data are reported as median (25-75 IQR) or N (%). * Only 31 and 13 parents from School 1 and School 2, respectively.

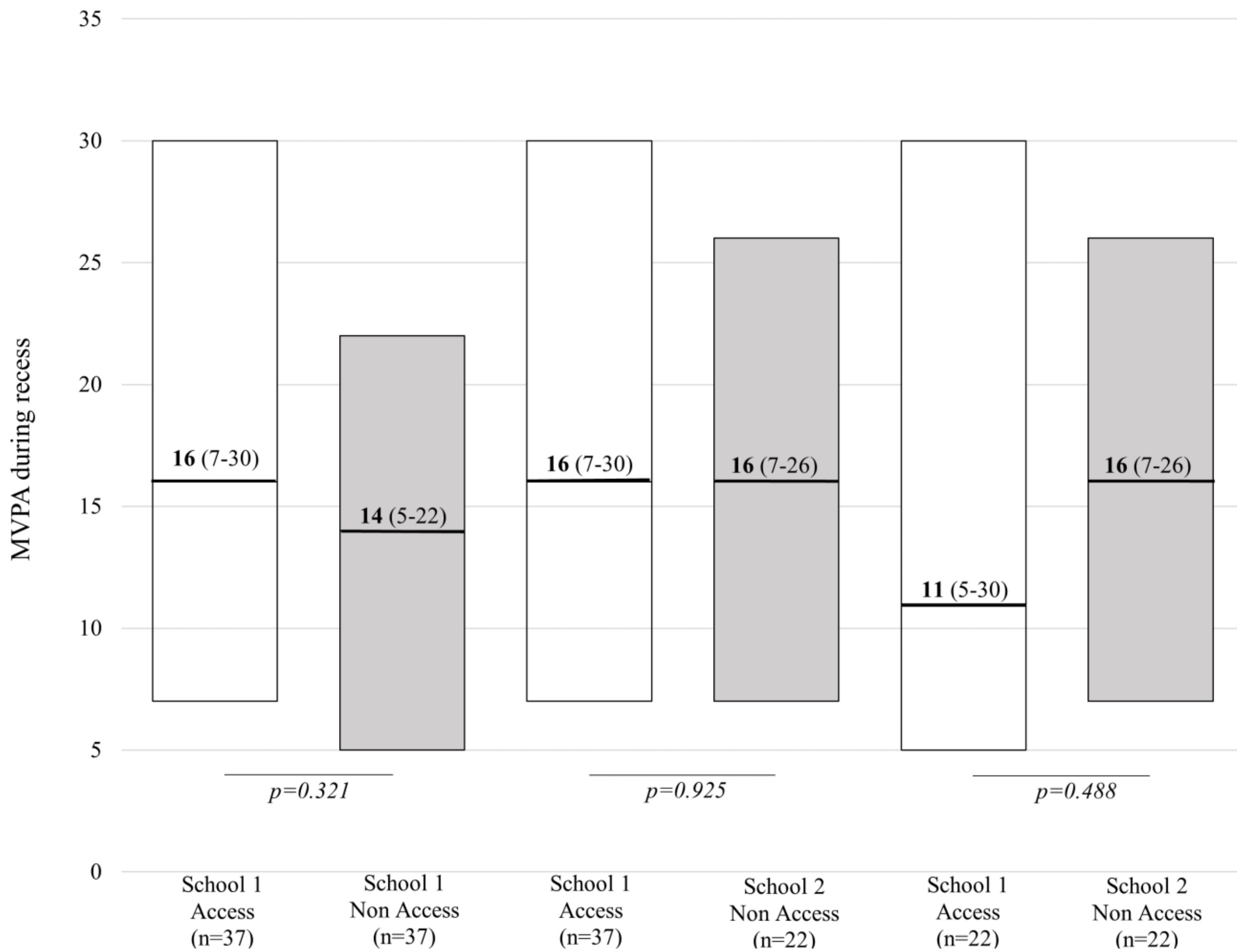

Fig. 1. Weekly minutes of MVPA during recess.

Data are presented as median (25-75 IQR)

Table 2. Minutes of MVPA

	School 1 (n=37)	School 2 (n=22)
Minutes of MVPA		
Week (7 consecutive days)	173 (104-266)	171 (130-298)
Weekdays (Monday-Friday)	120 (89-225)	125 (100-247)
Weekend (Saturday-Sunday)	17 (7-46)	31 (21-53)
School time (5 school days)	80 (50- 132)	81 (46-148)
Meeting aerobic guidelines (60min/day)	7 (19)	4 (18)

Data are presented as median (25-75 IQR)

Table 3. Quantile regression of MVPA during Recess (*n*= 59)

	Coefficient	95% CI	p-value	Model statistics
	20.92	-37.45 – 79.31	0.47	
Access to play structures (Yes)	-1.79	-11.06 – 7.47	0.69	
Age (years)	-1.95	-9.04 – 5.15	0.58	Pseudo R Squared = 0.18; MAE=8.64
Sex (male)	7.96	-0.71 – 16.63	0.07	
Weekly MVPA without recess (minutes)	0.06	0.04 - 0.09	<0.001	
Parent’s physical activity (score)	-0.01	-0.21 - 0.18	0.85	

Abbreviations: MAE: Mean Absolute Error; MVPA: Moderate to vigorous physical activity.

Appendix A

Timeline

Date	Activity	Person in charge
September 14 to 16, 2022	Inform parents about the project via email. FYI Sheets.	Principals
September 23, 2022	Delivery of envelopes with forms for parents to the principal's office.	Research staff
September 26, 2022	Distribution of envelopes to targeted groups.	Principals
September 27 to 29, 2022	Send parents an envelope with all forms and questionnaires via their children's backpacks.	Teachers
September 29 to 13 October 2022	Parents and children read, sign, and fill out all forms and return the envelope via the child's backpack.	Parents
October 3 to 7, 2022	Send a reminder to parents to fill out the forms and send them back	Principal
October 13, 2022	The last day to return the envelope with forms and questionnaires.	Parents
October14, 2022	Teachers take the box with envelopes and forms to the principal's office.	Teachers
October 14, 2022	Research staff will pick up the envelopes at the principal's office	Research staff
October 20, 2022	Delivery of Fitbits to the Principal's office	Research staff
October 21, 2022	Distribution of Fitbits to targeted groups	Principal
October 21, 2022	Selected children will receive a Fitbit and start wearing it.	Teachers

October 21 to 27, 2022	Children will wear Fitbit and perform their usual routine.	Children
October 27, 2022	Last day of wearing the Fitbit	Children
October 28, 2022	Last day to return the Fitbit to teachers	Children and parents
October 28 to 31, 2022	Teachers take the box with Fitbits to the Principal's office.	Teachers
October 31, 2022	Research staff will pick up the Fitbits at the Principal's office.	Research staff

Appendix B

Phyton Code for data extraction

```
#set these values
Participant_Code = ‘000_00’
Group = x

import pandas as pd
import numpy as np
import os
import tkinter as tk
from tkinter import filedialog

root = tk.Tk()
root.withdraw()

Path=filedialog.askdirectory(title="Select a directory")
os.chdir(Path)
allFilesArray=os.listdir(Path)
#--------------------------------------------------
for file in allFilesArray:
 os.chdir(Path)
 File=file
 Data_Frame = pd.read_excel(File)

 #Create the last row, you must comment on the following fragment if you want to see
the graphs

 lastIndex=Data_Frame.index[-1]+1
 time= Data_Frame.at[Data_Frame.index[-1],’Time’]
 year=time.year
 month= time.month
 day=time.day

 newDate=pd.Timestamp(year,month,day,22)

 Data_Frame.loc[lastIndex+1]=[newDate,np.NaN]

 #----------------------------------------------
 Date_Time = Data_Frame[‘Time’].astype(str).str.split(‘ ‘, expand=True)
 Data_Frame = pd.concat([Data_Frame[‘Time’], Date_Time, Data_Frame[‘Heart
Rate’]], axis= 1)
 Data_Frame.columns = [‘TimeCode’,’Date’,’Time’,’HR’]
```

```
Data_Frame = Data_Frame.set_index('TimeCode')
print(Data_Frame)

#Plot the HR Data to View it
# import matplotlib.pyplot as plt
# plt.plot(Data_Frame['Time'], Data_Frame['HR'])
# plt.show()

#Step 1: Remove HR < 40 bpm or HR > 200 bpm
Data_Frame = Data_Frame.drop(Data_Frame[(Data_Frame.HR < 40) |
(Data_Frame.HR > 200)].index)

def TimeString(N_Minutes):

if N_Minutes < 0:
Hours = 0
Minutes = 0

Hours = int(N_Minutes/60)
Minutes = int(N_Minutes % 60)

if Hours < 10:
Output_String = str(0)+str(Hours)+':'+str(Minutes)+':00'
else:
Output_String = str(Hours)+':'+str(Minutes)+':00'

return(Output_String)

# Step 2: Get min HR from 10pm and 7am
#Get the RHR start and end times
RHR_Start = TimeString(0)
RHR_End = TimeString(420) #420 minutes = 7 am

RHR_Section1 = Data_Frame.between_time(RHR_Start,RHR_End)

RHR_Start = TimeString(1320)
RHR_End = TimeString(1439) #420 minutes = 7 am
RHR_Section2 = Data_Frame.between_time(RHR_Start,RHR_End)

RHR1 = RHR_Section1['HR'].min()
RHR2 = RHR_Section2['HR'].min()

RHR = min(RHR1, RHR2)
print(RHR)
```

```
useMinThrougth=False
if(np.isnan(RHR)):
print(‘Using Min from throughout the day’)
RHR = Data_Frame[‘HR’].min()
useMinThrougth=True

##Step 3: Calculate the HRR
MaxHR = 200
Data_Frame[‘HRR’] = (Data_Frame[‘HR’]-RHR)/(MaxHR-RHR)*100

#Pull the waking day out and look for HRR

#Looking for missing time frames:
MinuteData = Data_Frame.resample(‘1T’).mean()
MissingMinutes = MinuteData[‘HR’].isna().sum()
print(‘MissingMinutes: ‘,MissingMinutes)

WholeDay = MinuteData.between_time(TimeString(420),TimeString(1320))
print(WholeDay)

MVPA_Threshold = 50
filt = WholeDay[‘HRR’] > MVPA_Threshold
Daily_MVPA_Minutes = len(WholeDay[filt])
print(‘Daily MVPA (mins): ‘,Daily_MVPA_Minutes)

#Get the group specific times
if(Group == 2 ):
SchoolDay = MinuteData.between_time(‘08:20:00’,’14:45:00’)
print(SchoolDay)
SchoolDayMins = len(SchoolDay[SchoolDay[‘HRR’]>MVPA_Threshold])
DataNotCorrupt = len(SchoolDay[SchoolDay[‘HR’]>-100000])
SchoolDayRecMins = DataNotCorrupt

Recess1 = MinuteData.between_time(‘10:00:00’,’10:20:00’)
Recess1_MVPA = len(Recess1[Recess1[‘HRR’]>MVPA_Threshold])

Recess2 = MinuteData.between_time(‘12:30:00’,’12:50:00’)
Recess2_MVPA = len(Recess2[Recess2[‘HRR’]>MVPA_Threshold])

Recess3 = MinuteData.between_time(‘12:10:00’,’12:30:00’)
Recess3_MVPA = len(Recess3[Recess3[‘HRR’]>MVPA_Threshold])
else:
SchoolDay = MinuteData.between_time(‘08:40:00’,’15:10:00’)
SchoolDayMins = len(SchoolDay[SchoolDay[‘HRR’]>MVPA_Threshold])
```

```
DataNotCorrupt = len(SchoolDay[SchoolDay['HR']>-100000])
SchoolDayRecMins = DataNotCorrupt
print("TIPO: ",type(SchoolDayRecMins))

Recess1 = MinuteData.between_time('10:10:00','10:30:00')
Recess1_MVPA = len(Recess1[Recess1['HRR']>MVPA_Threshold])

Recess2 = MinuteData.between_time('12:10:00','12:30:00')
Recess2_MVPA = len(Recess2[Recess2['HRR']>MVPA_Threshold])

Recess3 = MinuteData.between_time('15:15:00','15:25:00')
Recess3_MVPA = len(Recess3[Recess3['HRR']>MVPA_Threshold])

#Generate output
#append the file to a CSV File

Ouput = ({
'Participant Code':Participant_Code,
'File':File,
'Group':Group,
'Resting HR':RHR,
'Whole Day Missing Mins':MissingMinutes,
'School Day Minutes Recorded':SchoolDayRecMins,
'Whole Day MVPA':Daily_MVPA_Minutes,
'School Day MVPA': SchoolDayMins,
'Recess 1 MVPA': Recess1_MVPA,
'Recess 2 MVPA': Recess2_MVPA,
'Recess 3':Recess3_MVPA,
'Use if':useMinThrougth
})
Output_DF = pd.DataFrame(Ouput, index=[0])
OutputFolder = 'C:/Users/mafer/Desktop/Recess20min'
os.chdir(OutputFolder)

#Write the file if the results file does not exist, otherwise append to the existing file
if not os.path.isfile('Resultados.csv'):
Output_DF.to_csv('Resultados.csv', index = False)
else: # else it exists so happened without writing the header
Output_DF.to_csv('Resultados.csv', mode = 'a', header = False, index = False)
```

Curriculum Vitae

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Universities Attended:

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Publications:

Fuentes Diaz, M.F., Bouchard, D.R. (2023) Role of play structures in physical activity levels among children. *In progress.*

Fuentes Diaz, M.F., Leadbetter B, Pitre V, Nowell S, Sénéchal M, Bouchard D.R. (2023) Synchronous Group-Based Online Exercise Programs for Older Adults Living in the Community- A Scoping Revie. *In progress*.

Conference presentations

Fuentes Diaz, M.F., Sénéchal, Bouchard, D.R. (2023) Role of school outdoor play structures on the physical activity level of children during recess: a pilot study. *Atlantic Provinces Exercise Scientists and Socioculturists 2023.* Moncton, NB, Ca.

Fuentes Diaz, M.F., Pitre, V, Sénéchal, Bouchard, D.R. (2022) Comparing online and in-person delivery of a fall prevention exercise program for aging adults. *NBHRF Health Research Week. Advancing New Brunswick: Using Research to Optimize Impact.* Fredericton, NB, Ca.

Fuentes Díaz, M.F., McCain, A., McGibbon, C.A., Carroll, M., MacKenzie, E., Sénéchal, M., & Bouchard, D.R. (2022) Validation study of online physical function testing for older adults. *Canadian Society for Exercise Physiology Conference*, Fredericton, NB, Ca.

Fuentes Diaz, M.F., Leadbetter B, Pitre V, Nowell S, Sénéchal M, Bouchard DR. (2022) Online exercise programs for older adults: What is offered and what are the potential benefits – A scoping review. *Canadian Active Aging Research Meeting*, Oshawa, ON, Ca.

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Fuentes Diaz, M.F., Portillo, M. (2017) Prevalence of flat foot and its relationship with type of shoes children wear. *IX Physiotherapy National Congress of the Mexican Association of Physiotherapy, National College of Physiotherapy*. Toluca, Mex.