THE ROLE OF PLAY IN THE PHYSICAL ACTIVITY LEVELS OF PARENTS AND CHILDREN

by

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A dissertation submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in
Public Health Sciences

Charlotte

2024

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ABSTRACT

LIGIA M. VASQUEZ-HUOT. The Role of Play in the Physical Activity Levels of Parents and Children. (Under the direction of DR. AUGUSTE BARFIELD)

Physical inactivity is known to be associated with an increased risk of chronic disease and decreased mental health. Adult caregivers of children ("parents") are less active and are at increased risk of stress and poor mental health compared to non-parents. Parents are also known moderators of their child's physical activity levels. Children are encouraged to participate in playful physical activity, or "active play," due to the child's natural inclination to play, but adult play or active play are less studied even though enjoyment is a key motivator for continued engagement in physical activity. This project aims to uncover what is currently known about active play in families, what resources and interventions are designed for parent-child active play, and what are parents' current perceptions of play, physical activity, and quality time with their children. The purpose of this dissertation is to inform and add to the literature about active play and its potential to increase physical activity levels in both children and their adult caregivers. The research is a three-project investigation of dyadic active play behaviors of parents and their children.

Peer-reviewed articles from three databases (PubMed, PsycINFO, and Web of Science) were searched to include those that described physical activity interventions that included parents and their children ages 6-11, measured PA at the parent level, and were available in English or Spanish. It was found that interventions that used play and behavior change theory are more effective at improving PA outcomes in participants than those that do not. Second, smartphone apps from the Apple App Store were reviewed to assess the availability of apps that are designed for children and/or families and include fun and physical movement. While most apps that met

inclusion criteria also met active play criteria, not all were truly designed to be used with another person, indicating that app developers do design apps for fun or entertainment, but not for that engagement to be done with a family member. Lastly, semi-structured interviews were conducted with mothers of daughters aged 6-10 years to learn how they spend time together in playful and active ways among others. Mothers described barriers to quality time with their children including work and other family members and that quality time was prioritized more than how active that time may be.

These findings underscore the importance that play can have on physical activity in both parents and children, but the interventions, resources, and parent understanding of that importance may not be as readily available or understood. Play and other enjoyable methods of physical activity should continue to be promoted to create active families that might be healthier together and throughout the lifespan.

ACKNOWLEDGMENTS

I would like to acknowledge the assistance of the University of North Carolina's Department of Health and Human Services librarian Beth Auten for her guidance in conducting the literature synthesis. I would also like to acknowledge the women who took time to speak to me and contribute their words on motherhood, physical activity, and play with their daughters. And finally, I would like to acknowledge my committee, Dr. Joshua Huot, and Dr. Jan Warren-Findlow, whose support and guidance never faltered throughout my work on this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BMI – body mass index

CI – confidence interval

CON – control group

INT – intervention group

LPA – light physical activity

MA – Mexican American

MET – Metabolic Equivalent of Task

MPA – moderate physical activity

MVPA – moderate to vigorous physical activity

NCLB – No Child Left Behind Act

NHANES – National Health and Nutrition Examination Survey

NLB – Non-Latino Black

NLW – Non-Latino White

OR – odds risk

PA – physical activity

PRISMA – Preferred Reporting Items for Systematic reviews and Meta-Analyses

RCT – randomized controlled trial

SB – sedentary behavior

VPA – vigorous physical activity

INTRODUCTION

While physical activity trends have increased over time in the United States (Centers for Disease Control and Prevention, 2015), only 23% of adults meet leisure-time physical activity recommendations (National Center for Health Statistics, 2018) and only 23% of children ages 6-15 meet the recommended 60 daily minutes of moderate-vigorous physical activity (The Child & Adolescent Health Measurement Initiative (CAHMI), 2017). Participating in regular physical activity (PA) reduces the risk of chronic disease and improves quality of mental and physical health (U.S. Department of Health and Human Services, 2018).

The United States Department of Health and Human Services (2018) recommends that adults should "move more and sit less throughout the day. Some physical activity is better than none (p.8)." To see improved health benefits, adults should perform at least 150 minutes to 300 minutes a week of moderate-intensity or 75 minutes to 150 minutes a week of vigorous intensity aerobic physical activity, or an equivalent combination of moderate-vigorous aerobic activity. Additionally, adults should perform muscle-strengthening activities of at least moderate intensity that involve all major muscle groups at least two days a week. The recommendations vary according to age group and are further differentiated in adults who experience chronic health conditions, pregnancy, or disability (U.S. Department of Health and Human Services, 2018).

Physical Activity and Health

PA has the potential for risks, but individuals should choose activities that are appropriate for their current fitness levels and health goals. By starting slow and gradually increasing how often and how long activities are performed, PA can be safe for essentially every person regardless of age or health status (U.S. Department of Health and Human Services, 2018).

Adults and Physical Activity

While only 23% of U.S. adults meet PA recommendations of both aerobic and muscle-strengthening activities, 53% meet aerobic activity recommendations (National Center for Health Statistics, 2018). Meeting PA recommendations decreases across the lifespan with 34% of adults in the 18-24 age range, 24% in the 25-64 age range, 16% in the 65-74 age range, and 10% of older adults aged 75 and older meeting PA recommendations (National Center for Health Statistics, 2018). Additionally, adults experience disparities in PA among race/ethnicity groups. In adults, 25% Non-Latinx Whites (NLW), 20% of Non-Latinx Black (NLB), and 21% of Latinx met leisure-time PA recommendations (National Center for Health Statistics, 2018).

Among sexes, men tend to be more likely to meet PA recommendations than women across the lifespan (National Center for Health Statistics, 2018). Overall, 27% of men aged 18 and older and 20% of women aged 18 and older meet aerobic and muscle-strengthening PA recommendations. Males aged 18-24 are the adult age group that have the highest percentage that meet PA recommendations with 39%, but only 28% of women in the same age group meet recommendations. Twenty-seven percent of males aged 25-64, 18% aged 65-74, and 13% aged 75 and up meet PA recommendations compared to 20% of females aged 25-64, 15% aged 65-74, and 8% aged 75 and up meeting recommendations.

Children and Physical Activity

Less than one-fourth of U.S. children are meeting PA recommendations of participating in at least 60 minutes of activity per week (The Child & Adolescent Health Measurement Initiative (CAHMI), 2017). Preschool aged children should be encouraged to participate in active play that includes a variety of activity types. Children aged 6-17 should do at least 60 minutes of moderate-to-vigorous PA (MVPA) each day. Most of that time should be spent in

moderate-to-vigorous aerobic activity and muscle and bone strengthening activities should be performed at least three days a week.

Minorities and low-income populations experience greater risk to chronic disease and obesity and are more likely to fall short of meeting physical activity recommendations across the lifespan (Kann et al., 2018; Keadle et al., 2016). The disparities in PA are sex and age specific in children similarly as in adults. Male children are more likely to meet PA recommendations than female children (Biddle et al., 2011; Hearst et al., 2012) and young children are more likely to meet recommendations than adolescents (The Child & Adolescent Health Measurement Initiative (CAHMI), 2017). Twenty-seven percent of male children meet PA recommendations compared to 19% of female children and 28% of children aged 6-11 meet PA recommendations compared to 18% of 12-17 year-olds (The Child & Adolescent Health Measurement Initiative (CAHMI), 2017).

Additional child PA disparities are seen based on race/ethnicity similarly as in adults. Black children ages 6-17 have the highest percentage among race/ethnic groups of children who meet PA recommendations with 25%, compared to 24% of White children, 21% of Hispanic children, and 16% of Asian children (The Child & Adolescent Health Measurement Initiative (CAHMI), 2017). These disparities are aggregated as well: A study found sex, age, and race/ethnicity differences among children using NHANES data with more boys aged 6-11 (Black: 57.4%, White: 45.8%, Mexican-American (MA): 51.8%) meeting PA recommendations at least 5 days a week compared to boys aged 12-15 (Black: 18.3%, White: 10.0%, MA: 17.9%) and boys aged 16-19 (Black: 13.7%, White: 8.7%, MA: 12.3%) (Whitt-Glover et al., 2009). Girls are generally less active than boys across all groups as well with more girls aged 6-11 meeting PA recommendations at least 5 days a week (Black 43.4%, White: 33.9%, MA: 30.2%)

compared to girls aged 12-15 (Black: 4.0%, White: 2.4%, MA: 2.9%) and girls aged 16-19 (Black: 3.5%, White: 5.6%, MA: 4.6%) (Whitt-Glover et al., 2009). While this study shows that Black and Mexican-American children are more (or similarly) active than their White counterparts, others have found that Latinx adults and children are one of the least active racial/ethnic subgroups (Kann et al., 2018; Keadle et al., 2016; Marquez et al., 2010).

Risks of Inactivity

Poor health outcomes of individuals who are sedentary have been observed for centuries (U.S. Department of Health and Human Services, 1996). Physical inactivity has been associated with increased risk of death for heart disease and cancer as well as increasing the risk of obesity, high blood pressure, and diabetes (McGinnis & Foege, 1993). Globally, over 3 million deaths each year can be attributed to physical inactivity (World Health Organization, 2014).

Children who are inactive tend to maintain sedentary behaviors and unhealthy weight throughout the lifespan, increasing their risk for obesity and chronic disease in adulthood (Alamian & Paradis, 2009). Children with higher levels of sedentary behaviors (greater than 2 hours of screen time each day) are almost two times more likely (1.73 crude OR) to be diagnosed with diabetes compared to children who are less sedentary (Urrutia-Rojas & Menchaca, 2006). Additionally, less active adolescents are more likely to have symptoms of heart disease including low cardiorespiratory fitness (OR: 1.56, 95% CI: 1.01-2.38 for 15 year-old females, ; OR: 2.00, 95% CI: 1.34-2.94 for 15 year-old males), elevated blood pressure (OR: 1.54 , 95% CI: 1.01-2.33 for 15 year-old males), and elevated cholesterol (OR: 1.54 , 95% CI: 1.08-2.22 for 15 year-old males) (Boreham et al., 1997). Similar trends are seen in younger children as well (Froberg & Andersen, 2005). These and other risk factors for metabolic syndrome begin to cluster in children as young as 9, but physical fitness reduces the likelihood of developing multiple risk

factors and therefore reduces the risk of being diagnosed with chronic disease (Andersen et al., 2003).

Higher levels of sedentary behavior such as watching TV or using computers are associated with lower levels of physical activity. Combined sedentary behavior and physical inactivity increases the risk of overweight by two in children (Sisson et al., 2010). The risk of overweight decreases as PA increases (OR: 0.87, 95% CI: 0.71-1.06 for 2-4 times per week vs. OR: 0.70, 95% CI: 0.54-0.91 for >7 times per week) as well as the risk for obesity (OR: 0.81, 95% CI: 0.58-1.13 [2-4 times per week] to OR: 0.65, 95% CI: 0.44-0.97 [>7 times per week]) (Veugelers & Fitzgerald, 2005). Overweight and obese children encounter additional health and social problems as well including: more likely to be bullied (Janssen et al., 2004), less likely to finish high school and have higher rates of poverty (Gortmaker et al., 2002), more likely to have a lower extremity injury (Pomerantz et al., 2010), more likely to miss days and perform poorly in school (Taras & Potts-Datema, 2005), more likely to have sleep-related disordered breathing (Wing et al., 2003), and more likely to experience depression or anxiety (Esposito et al., 2014). Obese children are also more likely to maintain obesity status in adulthood (Webber et al., 1991). Obesity in adulthood is also linked to chronic diseases such as diabetes and heart disease (Hassan et al., 2003) and additional poor health and social outcomes such as stroke, pregnancy and surgical complications, depression, social exclusion, disordered eating, arthritis, and discrimination (Bean et al., 2008).

Forms of Physical Activity

There are many ways to combat physical inactivity and decrease the aforementioned risks to diminished health. PA, defined as a behavior that occurs due to repeated skeletal muscle contractions which increases energy expenditure above resting metabolic rate (Durstine et al.,

2009), can take many forms including structured PA such as exercise, or lifestyle PA such as active transportation or activities of daily living. Exercise, a subcategory of PA that is planned, structured, and intentional in improving physical fitness, is generally further categorized into aerobic, muscle-strengthening, or stretching activities.

While many individuals understand and acknowledge that exercise is beneficial in improving health and quality of life, it is still difficult to meet PA recommendations. It has been postulated that the term "exercise" has a more negative connotation than "physical activity" (Segar et al., 2012). This could lead to diminished adherence to an exercise prescription from a medical provider or fitness professional. In fact, "physical activity" prompts associations with physical labor among older adults, insinuating that that term may also prove to stir feelings of work in some individuals (Aronson & Oman, 2004).

To boost the motivation to exercise, individuals should choose an activity that is enjoyable and is within one's perceived abilities (self-efficacy) to increase motivation to partake in PA (Garber et al., 2011). One study found that individuals increase their caloric intake as a reward after completing an activity if it is framed as exercise as compared to a fun activity (Werle et al., 2015). Additionally, mood and levels of fatigue were more favorable in the "fun" group compared to the "exercise group." By reducing caloric intake, feeling less fatigued, and perceiving an activity as fun, activities can aid in improving the health outcomes that come with increased PA such as reducing depression and improving fitness.

Because play is an activity that can increase energy expenditure, it is suggested by the US Department of Health and Human Services (DHHS) as a method to increase PA in children, as it is generally perceived as enjoyable (U.S. Department of Health and Human Services, 2018). Additionally, "play" has a more welcoming connotation than "physical activity" (Curtis et al.,

2012). Play lacks specific rules or regulations such as location (e.g. Baseball diamond, recreation center, etc.) or objects (e.g. weightlifting equipment or balls) that are needed in order to participate (although these may be incorporated spontaneously), therefore it may increase PA levels in additional populations that are unable to meet recommendations such as adults. The proposed study will investigate whether play, specifically "active play," connoted by increased energy expenditure, may be an adequate moderator for PA for both parents and young children (ages 6-10).

With low rates of physical activity among both adults and children, it is possible that active play can increase energy expenditure in families if they play together. If the play activity involves movement like exercise, it is possible that both the adult and child gain similar benefits from play as they would from a structured activity such as exercise. Through learning concepts such as modeling, it is also possible that play can lead to active lifestyles throughout the child's lifespan. Play has not been studied as a potential influence in physical activity levels in adults or in children together with their adult caregivers.

Research Question

Most adults and children in the United States are not meeting recommendations for physical activity levels with potentially serious future health consequences. Physical activities that can be done together, among parents and children such as play, may provide an opportunity to increase PA in both parties, particularly in groups that are less likely to meet PA recommendations such as minorities, females, and adults. This dissertation research will inform the research question: What is the potential role of active play in improving physical activity among adults and children?

Play

Play has been determined a basic human need (Murray, 2007) and a basic human right (Office of the United Nations High Commissioner for Human Rights, 1989). Play enhances creativity, develops physical, cognitive, and emotional skills, aids in brain development, and with children it teaches them to interact with the world around them through imaginative play, social play, and active play (Ginsburg, 2007). Play is difficult to define due to its broad nature although it has been consistently characterized as a fun or enjoyable activity (Van Vleet & Feeney, 2015). Play has been defined as "an ancient, voluntary, 'emergent' process driven by pleasure that yet strengthens our muscles, instructs our social skills, tempers and deepens our positive emotions, and enables a state of balance that leaves us poised to play some more (Eberle, 2014)." Observation tools to assess play among children have incorporated additional characteristics that aid in the fluid definition of play previously identified from research. These characteristics include: Parten's (1932) characteristics of social play (Broadhead, 1997; Coplan & Rubin, 1998; Jarrott et al., 2008; Rubin, 2001); the idea that play is freely chosen (Barnett, 2013; W. H. Brown et al., 2006); indicators of child development (Farmer-Dougan & Kaszuba, 1999); and markers for physical intensity (Bakker et al., 2008; Barnett, 2013; W. H. Brown et al., 2006; Ridgers et al., 2010).

We engage in play differently throughout the lifespan, receiving diverse benefits at each stage. For example, in infancy, parents and children attune, or become synchronized physiologically, through play such as "peekaboo" or "pat-a-cake" (S. L. Brown, 2009, p. 82); this aids the child to learn how to be sensitive to and identify with the other person's sensations, needs or feelings (Erskine, 1998). Children (and as they grow into adults) then progress to body and movement play, object play, imaginative play, social play, storytelling and narrative play, and transformative-integrative and creative play (S. L. Brown, 2009) with benefits such as

communication skills, improved motor skills, rule-following, and creativity. Play in adulthood provides mental and physical stimulation, aids in flexible thinking patterns and improved problem-solving abilities, and provides a means of reducing the impact of stress (Van Vleet & Feeney, 2015). Types of play seen in children and adults will vary depending on developmental stages, age, skill, and preference.

Types of Play Related to Energy Expenditure

Active play is defined as a form of gross motor or total body movement where individuals exert energy in a *freely chosen, fun, and unstructured manner* (Truelove et al., 2017). Active play (also referred to in the literature as "movement" or "physical" play) supplements the social, emotional, and cognitive benefits of play with the physical benefits of being active. Through play, young children learn motor skills and textures of objects, and older children gain strength in bones and muscles by running, jumping, and even falling.

While research has identified a myriad of play types, this proposal discusses three primary types of play that have the capacity to be active play: 1) body and movement play, 2) structured play, and 3) object play. These types of play are not meant to be mutually exclusive but meant to include the various types of play one might participate in throughout the lifespan incorporating the benefits that can be brought on through physically active play. Generally, play can be subcategorized into several characteristics of interest such as structured vs. unstructured, movement vs. sedentary, and child-led vs. adult-led. In order to highlight the physically active differences between adult and child play, this section will categorize movement play into child-led and adult-led.

Child-led play

Child-led play is of particular interest because it provides children an opportunity to practice developing their unique self, increasing their awareness of the personal and social relationships they encounter, and most importantly, empowering them to develop as individuals (Canning, 2007). When children direct the play activity, the goal is to have fun. In contrast, adults consider play to have an "outcome" such as learning or activity and applying that adult agenda can disempower children (Canning, 2007).

Body and Movement Play

Moving during play engages the brain and fosters learning, creativity, adaptability, and resilience (S. L. Brown, 2009, p. 84). Similar to PA, movement play can improve attention, gross motor skills, and increase energy expenditure. This type of play can be comprised of games or symbolic play and includes playground activities, ball games, and backyard games such as Capture the Flag (Janssen, 2014), and may even include some screen-based games like Nintendo Wii or Xbox Kinect. Some of these games may have rules, but those rules are known to be fluid based on the children who are playing. For example, "Tag" has basic rules ("you're it!"), but there are hundreds of variations including freeze tag, toilet tag, Band-Aid tag, etc.

Movement is primal – humans move as early as in the womb – and pleasure is gained from intrinsically playful movements that infants make such as exploratory body movements and early speech (S. L. Brown, 2009). Movement improves mood and decreases anxiety and depression by releasing endorphins (U.S. Department of Health and Human Services, 2018). Because movement improves mood, and play is inherently an enjoyable activity, often simply being physically active can be playful.

Non-competitive Play. While competition may drive enjoyment for many children, there are also a variety of games that employ teamwork or simply movement for fun that also provide benefits. For example, many children grow up with trampolines or may ask for a bounce house at their birthday party. Additionally, children frequently create obstacle courses where half of the fun comes from creating a course from available items. Recently, a viral "challenge" led adolescents and adults to seek higher ground if someone yelled "the floor is lava!" proving that fun can be had in any location under any circumstance (Hathaway, 2017).

As Sobel (1985) writes:

> "Through this kind of play, we learn teamwork, trust, and group unity. The emphasis is on total participation, spontaneity, sharing, the joy of play, acceptance of all players, playing our best, changing rules and boundaries to suit the players and recognizing that *every* player is important. We don't compare our differing abilities and past performances, we don't emphasize winning and losing, results and standings (p.30)."

Non-competitive play may also be object play as with the trampolines above. Objects may promote activity such as jump-ropes or they can be sedentary in nature such as playing with dolls or some board games (excluding those which employ some sort of movement and an aspect of competition such as Twister or Cranium). Younger children default to non-competitive games due to their inability to grasp the concept of winners and losers. Many times, they receive enjoyment from simply building a tower and knocking it down.

Non-competitive play is not necessarily unstructured, but due to the decreased likelihood of rules (or the flexibility/disregard for them) and the lack of winners or losers, this type of play is inherently without structure. Structured play is likely preferred as individuals age because it mimics the increased structure within day-to-day lives (school days, workdays, scheduled

practices or other activities, etc.). Comfort with structure then overlaps with adult-involved or adult-led play, where there are clear goals to the activity.

Adult-involved Play

Adults can be involved in children's play in two ways, adult-led and adult-involved. Adult-led play involves adult planning, organization, and leadership of children in a play activity (Pearson, 2019). Examples may include sport-related games or physical education (PE) where adults take the role of coach or teacher where they plan the activities as well as the duration and order. The potential benefits of adult-led play include the ability to allow children to carry out higher risk activities under supervision, teaching them how to use objects safely, and it supports children learning specific skills and experiences that can enhance knowledge, skill, or health (Pearson, 2019). Adult-led play may also limit creativity or independence. A second type of adult-involved play is adult-initiated play: activities where an adult provides the resources or objects that prompt children to play in a certain way (Pearson, 2019). This type of play can encourage children to develop new concepts and practice skills, but depending on the guidance provided, children may not understand what to do, and therefore not benefit as expected. With both types of play, adults are providing a structured environment, albeit the structure can be on a spectrum of overly planned to simply providing prompts.

Structured Play

In recent decades, opportunities for free play for the average school-aged child have been greatly diminished, due to US public schools' focus on academics starting in 2001 with President George W. Bush's "No Child Left Behind Act (NCLB)" (Ginsburg, 2007; Henley et al., 2007). Classroom time was increased in order to pass state and federal assessments leading to a decreased focus on non-instructional time such as recess and subjects that can be considered

playful such as art and music. PE classes became children's opportunity for play, although those activities are often adult-led, adult-initiated, and generally structured. While reducing opportunities for play was not an intended consequence of NCLB, states noticed a decrease in PA and an increase in child obesity. Those states that imposed PE mandates to counteract the reduced time for PA in the NCLB era did provide increased PA levels in children in grades 3-8 (Schneider & Zhang, 2013).

There is a debate among play researchers whether structured play such as team sports has as much of a benefit on child health and development as unstructured play. Bailey (2006), Pedersen & Seidmen (2004), and Wiersma (2000) concluded that PE and organized sport have the potential to make significant contributions to the development of children's movement skills and physical competences, social skills, self-esteem, and cognitive development, but there is also the pressure that can lead to emotional or physical burnout in structured play such as sports (Wiersma, 2000). Some children may feel forced to play team or organized sports which can lead to feelings of frustration and anxiety, especially if the child does not feel ready due to skill level or sport or social readiness (Purcell, 2005). Frustration with team sports can lead to burnout, hindering psychological development in children (Breuner, 2012).

The ultimate takeaway is that play should be fun and the activity should be freely chosen, so if a child chooses a team sport or a game with rules then this is how they choose to play. Being part of a team, receiving mentoring, modeling, and friendship from young adult coaches, and having opportunities to demonstrate skills in front of friends and family may be fun for some children and therefore they consider it, play. Children are taught about team sports primarily through "fun" activities and when team sports are fun, children continue to participate (Merkel, 2013; Purcell, 2005).

The benefits of structured play may be mediated by the interactions between children and the teachers, parents, and coaches (Bailey, 2006). This indicates that social support may be the important construct from structured play and it is likely that not all children will experience the same benefits. Participation in team sports should be encouraged by adults, but over- or under-supporting children can also lead to attrition and therefore less active lifestyles (Breuner, 2012). While social support has the potential for negative effects in children, it can also lead to benefits in development. The social nature of organized sports has shown evidence in reduced anxiety in children, including shy children (Dimech & Seiler, 2011; Findlay & Coplan, 2008).

Object Play. This type of play teaches individuals about object manipulation and can include something as easily accessible as a cardboard box or rocks and sticks that are found outside or something more expensive such as a bicycle or video game console. This type of play is not limited to adult-led/initiated play or child-led play as many structured active play games involve a ball or other sport equipment. Children can also use a variety of objects, using their creativity in deciding how it will be used in a fun manner. An obvious object that encourages play is a toy, and many toys have the capacity to increase movement such as bicycles or balls. Objects such as toys, equipment, and permanent play structures are positive correlates of activity in youth (Biddle et al., 2011; Pfeiffer et al., 2009).

Play and Physical Activity

Active play provides an opportunity for physical activity in children and youth (Physical Activity Alliance, 2024). Play allows children to be creative and develop their imagination, dexterity, and physical, cognitive, and emotional strength, ultimately aiding in the development of a healthy brain (Ginsburg, 2007; Milteer et al., 2012). Child caregivers (henceforth called “parents”) are the individuals with whom children first play, usually learning motor skills and

gaining strength through movement play, and it is important to explore the parent-child relationship in play to develop healthy brains and bodies, not only in children, but in adults as well.

Play has increasingly been studied to improve PA levels in children (Alexander et al., 2014; Appelhans & Li, 2016; Cortinez-O'Ryan et al., 2017; Truelove et al., 2018). Play throughout the lifespan is important, but physical activity and play interventions have focused solely on the outcomes of the child, even if the intervention was dyadic (O'Dwyer et al., 2012). Even dyadic PA studies that do not specifically focus on play primarily examine the child outcomes, believing that the parent influences child outcomes, not the other way around. Little research has shed light on the context of parent-child PA or the influence of child PA on parent PA, but there is evidence that child PA has an influence on parent PA (Dunton et al., 2012; Tate et al., 2015).

Adults should also participate in play because it allows for creativity and self-expression, promotes fun and reduces stress, aids in learning to take things in stride, and models lifelong play for children (Baptiste, 1995). Adult play and playfulness is largely lacking in research (Proyer, 2017).

Active Play in Children

Through play, young children learn skills and gain strength. In animal studies, rats raised without active play have shown deficiencies in the medial prefrontal cortex, an area of the brain that is associated with social interaction (Bell et al., 2009). When rats are prevented from playing together (including play-fighting), they will be more behaviorally rigid and will exhibit impaired rule learning compared with rats that are allowed to play together (Fletcher et al., 2013). Low-income children who may not be receiving the maximum benefits of play due to safety concerns,

parents with high stressors, and less accessible play spaces may experience some of these characteristics, although it has not been studied (Milteer et al., 2012). Only children may also experience a diminished play experience due to a lack of play mates in the home; only children are more likely to be aggressive and tend to be less liked by their classmates (Kitzmann et al., 2002). Play and active play have social and cognitive benefits, but active play includes the benefits of physical activity.

Younger children are more interested in play than adolescents or adults due to increased opportunity for play (recess, PE, after school programs), the expectation for play (providing toys as gifts, play dates with other children), and their intrinsic desire for play. Many active play interventions are targeted towards young children (2-5 years old), likely because many children spend large portions of their day in childcare centers or schools, and childcare centers provide more opportunities for play and provide more ideal opportunities for observation for research purposes. Due to adolescents (aged 13+) decreased interest in unstructured play as well as decreased interest in participating in activities with parents, the focus of this research will be on school-aged children (5-12 years old), an age-group where PA data is still lacking (Rhodes et al., 2017a).

Active Play in Adults

Play behaviors and frequency vary among the lifespan, following an inverted-U shape where it begins in infancy, peaks in childhood, and declines again in adulthood (Pellegrini & Smith, 1998). To date, only one study has actually examined active play and PA in adults, which included using active video games in adults with schizophrenia (Kimhy et al., 2016). An additional article mentioned using active play in an intervention targeted towards healthy gestational weight gain and postpartum activity in women, but there is no information whether

the active play was intended for the mother, the mother and child, or solely the child (Atkinson et al., 2016).

In adults, PA appears to be performed more for functional purposes and less so for the purpose of joy or enjoyment compared to children (Hulteen et al., 2017; Thiel et al., 2016). This could either create a barrier with adults partaking in active play, or it may be that PA again needs to be framed in a more enjoyable way. Thiel et al. (2016) concluded that playful PA activities are socially contagious, therefore indicating that adults likely simply want to enjoy active play with others.

Problem Statement

Most adults and children in the United States are not meeting recommendations for physical activity levels. Play, and active play specifically, is a natural activity among young children, and parents are a key playmate for them throughout their childhood. Thus, active play may provide opportunity for PA in both adults and children, particularly in groups that are less likely to meet PA recommendations such as minorities, females, and adults. While play is deemed important in adulthood it is unknown how play can increase physical activity levels in adults.

Purpose

The purpose of this dissertation is to inform and add to the literature about active play and its potential to increase PA levels in both children and their adult caregivers. The research is a three-project investigation of dyadic active play behaviors of parents and their children.

1. Paper 1 is a literature synthesis in order to determine what is currently known about parental engagement and active play in dyadic physical activity interventions with school-aged children (6-10 years old) and their parents.
2. Paper 2 is a review of mobile apps related to promoting physical activity in children (ages 6-10). The purpose is to assess the apps' focus on both play and physical activity as well as any participatory inclusion of adult caregivers.
3. For paper 3, qualitative, semi-structured interviews were conducted with mothers of female children (6-10 years old) on their perceptions, behaviors, and barriers to physical activity and active play in themselves, their child, and when together.

This project addresses gaps in play research by exploring the parent-child play relationship, learning about how play affects parent physical activity, and learning if play can be used to influence parent-child dyads' physical activity. By examining more about how parents play with their school-aged children (6-10-year-olds) can lead to informing quality physical activity interventions that may increase the percentage of the population who meet physical activity recommendations.

ARTICLE 1: PLAY IN PARENT-CHILD PHYSICAL ACTIVITY INTERVENTIONS: A SYSTEMATIC REVIEW

An original review article submitted to Journal of Physical Activity and Health on October 8, 2024 by:

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Abstract

Background: While there is an abundance of physical activity (PA) interventions for children, parents are rarely included and if they are, their PA levels are not likely to be measured as well. Active play, PA that is geared towards fun and games, has been encouraged for children to increase PA levels, but it is unknown if playful interventions are more effective in improving PA levels in children or adults. ***Methods:*** Peer-reviewed articles from three databases (PubMed, PsycINFO, and Web of Science) were searched to include those that described PA interventions that included parents and children ages 6-11, measured PA at the parent level, and were available in English or Spanish. ***Results:*** Searches identified 20 articles describing 15 unique PA interventions. Interventions were diverse with different settings, samples, and designs. Most interventions were theory-driven and focused on PA outcomes of the child or the dyad. Most interventions also used play in some capacity to improve PA in children and/or the parent-child dyad. Effective interventions were more likely to use play and theory in the design. ***Conclusions:*** This review systematically identified how play and other aspects of PA interventions influenced the effectiveness of improving PA in school-aged children and their parents. Using play in PA interventions can be a useful tool to engage both child and adult populations in PA and potentially remain engaged after the intervention is over to promote active lifestyles.

Introduction

Physical inactivity is linked to about $117 million in annual U.S healthcare costs due to its known relationship to various chronic diseases such as cardiovascular disease, type II diabetes, and cancer as well as non-communicable diseases such as hypertension and dementia (Katzmarzyk et al., 2022; U.S. Department of Health and Human Services, 2018). In addition to physical health, physical activity (PA) also improves quality of mental health across the lifespan (U.S. Department of Health and Human Services, 2018), but less than one in four children and adults meet recommended levels of PA (National Center for Health Statistics, 2018; The Child & Adolescent Health Measurement Initiative (CAHMI), 2017). Primary adult caregivers of children (henceforth called "parents") are less active than non-parents and mothers are generally less active than fathers (Bellows-Riecken & Rhodes, 2008; Gaston et al., 2014; Palomäki et al., 2023). Non-parents get almost two hours more PA per two weeks than parents and fathers get approximately an hour more PA per two weeks than mothers (both $p<.001$; Nomaguchi & Bianchi, 2004). Barriers of PA for parents include a lack of leisure-time and social support, fatigue, childcare, and other familial commitments (Bellows-Riecken & Rhodes, 2008; Candelaria et al., 2012). Barriers of PA for children include perceived safety, weather, and parent time and resources (Hesketh et al., 2017; Ling et al., 2016; Ross & Francis, 2016). While there are PA intervention studies that involve both children and adults, little research has shed light on the context of parent-child PA or the influence of child PA on parent PA, but there is evidence of intergenerational transmission, that child PA has an influence on parent PA (Dunton et al., 2012; Tate et al., 2015).

A common motivator for both adults and children to participate in PA is enjoyment in the activity itself. To boost the motivation to be active, individuals should choose an activity that is

both enjoyable and is within one's perceived abilities (Garber et al., 2011). "Play" is an activity done for enjoyment and has the potential to be active. Physical activities that can be done together among parents and children, such as play (e.g. riding bicycles, playing sports, outdoor games like "tag"), may provide an opportunity to increase PA in both adults and children. Active play is a type of play that has been increasingly studied in child PA due to play being a necessary part of child development and its capacity to increase energy expenditure. Truelove et al. (2017) defined active play as a "form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner." This definition maintains the characteristics of play such as "freely chosen" and "fun" while preserving the focus on PA in that active play is a "total body movement."

Adult participation in play enhances creativity and self-expression, promotes fun and reduces stress, aids in problem solving and learning to take things in stride, and models lifelong play for children (Baptiste, 1995; Van Vleet & Feeney, 2015). Social Cognitive Theory is a frequently cited behavior change theory in PA literature due to the construct of modeling as an environmental factor in learning (Bandura, 2004). Through the reciprocal and environmental process of modeling, play can lead to an active lifestyle throughout a child's lifespan if a parent is also playful and active. Play has not been studied as a potential influence in PA levels in adults or in children together with their parents. Interventions to increase child PA are abundant throughout the literature and while they often involve some adult involvement (such as teachers, coaches, or parents) they often focus primarily on child outcomes. This appears to also be true in active play literature, as play is often thought of as a child's activity and parents are seen as a modifier for child's PA.

Identifying parents as change agents for health behaviors, such as increasing PA, is more successful than targeting children alone (Spear et al., 2007). It is known that there is a strong relationship between parent and child PA. Parent levels of PA, parental support, and parent/child sex have been consistently found to correlate to child levels of PA (Gustafson & Rhodes, 2006; Petersen et al., 2020). Parent-child dyadic moderate-vigorous PA is influenced by household income, child age, and child sex and dyadic sedentary behavior is increased if the child is a female and as the parent/child age (Dunton et al., 2012). Child age is of particular importance because interventions tend to target early childhood to improve the relationship with PA as early in the lifespan as possible. This period is also when new parents are more receptive to support for healthy behavior change (Crumbley et al., 2020). Additionally, while PA decreases across the lifespan, interventions involving adolescents aged 11 years and older and their parents become more difficult as that relationship becomes more egalitarian (Branje, 2018), suggesting a need to create interventions that keep both the parent and child engaged. The primary school age range (6-10 years old) provides a population that is generally healthy but begins to see negative health behaviors such as sedentary activity. Since they still spend most of their time in schools or home where they are supervised by adults, these settings are ideal for interventions (Zurc & Laaksonen, 2023). Additionally, parental PA begins to increase and reach similar levels to non-parents once children reach school age (Gaston et al., 2014; Palomäki et al., 2023). Due to the higher potential of modeling in primary school age children and the increased capacity for parents to be involved in PA, this review will focus on interventions where the child is between 6-11 years old.

While there are various reviews assessing parent-child PA correlates, (Bingham et al., 2016; Boxberger & Reimers, 2019; Gustafson & Rhodes, 2006; Hinkley et al., 2008; Yao &

Rhodes, 2015) it is unknown if dyadic play can influence PA in either a parent or a child. PA interventions that include an adult often measure PA at the child level, but not in both parties. PA interventions that use play modalities also may not highlight that the PA is meant to be fun, unstructured, or freely chosen as is specific to play. To learn about how play may or may not influence PA, a literature synthesis will be conducted to answer the following research questions: 1) What is currently known about the design and outcomes of parent-child physical activity interventions? And 2) Does play influence the effectiveness of a parent-child physical activity intervention?

Methods

Eligibility Criteria

A literature synthesis was performed in fall of 2022 to find empirical articles that describe parent-child interventions using play and have PA as an outcome of interest. Studies were included if PA was measured and reported in at least the parent participants. Studies were excluded from the review if they did not include a play or PA intervention and if they did not measure PA levels as an outcome. Because play is consistently described as a subjectively fun and enjoyable activity, particular interest was placed on interventions that assessed affect or enjoyment in the activity in some aspect, as well as those that used multi-level interventions to determine the possible relationship of play and PA in parents. Relevant systematic reviews were assessed in detail for additional articles not captured by the search terms. Publications were also excluded if they were not available in either Spanish or English languages, but geographic location of the study was not an exclusion criterion.

Search Strategy

PRISMA guidelines for literature syntheses was followed (Moher et al., 2009). The search included peer-reviewed articles and dissertations published from 2011-2021 and available in PubMed, PsycINFO, and Web of Science databases. A comprehensive list of search terms was determined with the assistance of a university librarian (Web of Science: "parent child play physical activity intervention"; PsycINFO: "MA parent-child AND (exercise or physical activity or fitness). Medical Subject Headings (MeSH) of (parent-child relations) OR ((parent AND child) AND (exercise OR physical fitness OR sports OR games, recreational OR play)) were used to capture all related search terms within the PubMed database.

A priori inclusion criteria comprised of presence of parents and children in the study sample, articles published in English or Spanish, and parent PA (measured objectively or subjectively) as an outcome of interest. To examine the potential that play and the dyadic nature of the intervention may have on PA, further exclusion criteria included those focusing on young children (0-5 years old) and adolescents (11-17 years old). Qualitative studies were included if all other criteria were met. A particular focus was placed on articles that discussed the barriers and perceptions of PA, those that used parent-child multi-level interventions, as well as articles that measured affect or enjoyment of activity.

Data Collection and Analyses

Eligible studies were reviewed for relevance and duplicates were removed (see Figure 1). Results from the search were cross-referenced and screened by title and abstract to ensure the study focused on parents and/or children and PA or play. A second independent reviewer assessed a sample (10%) of the articles for relevance, ensuring that the selection met the

inclusion and exclusion criteria. The two reviewers discussed any disagreement in article inclusion until a full consensus was reached.

Full-text articles were obtained and reviewed if studies met the initial screening criteria, or the inclusion/exclusion criteria could not be determined from the abstract. Additional articles were included from reference lists of relevant review articles from the search and in instances where a follow-up search was considered necessary (i.e., searching for an outcomes paper of a protocol article that was assessed).

Information was abstracted from each full-text article on the sample of interest, intervention design, level of parent involvement, and study results. Additionally, intervention features such as type of PA intervention, type of PA measure, if the intervention was theory-driven, and if there was any indication the intervention used any aspect of "play" or "fun" were abstracted from the publications by the first author. A data abstraction matrix was used to record components of interest of each intervention (listed in Appendix 1.1)

Results

Searches provided 1005 unique references and after screening and full-text review, twenty articles were identified describing 15 unique interventions that met eligibility criteria. A flow diagram detailing the article identification process is shown in Figure 1.

Interventions

Table 1 describes the main components of the interventions including the descriptions of samples and population, length and delivery of intervention program, setting and theories.

Samples

Selected interventions included sample types that recruited primarily parents (Gunawardena et al., 2016; Jago et al., 2013; Raynor et al., 2012; Tuominen et al., 2016), dyads (Boutelle et al., 2017; Karmali et al., 2020; Tuominen et al., 2017, 2018, 2020), families (including one parent with multiple children) (Barnes et al., 2015; Ha et al., 2021; Holm et al., 2012; Morgan et al., 2011, 2014, 2019; Morrison et al., 2013; Schoeppe et al., 2020) or primarily children (Boutelle et al., 2017; Centis et al., 2012; Maddison et al., 2014). In primarily parent samples, sample size ranged from 13 mothers (Tuominen et al., 2016) to 261 mothers (Gunawardena et al., 2016). Dyad samples ranged from 50 (Karmali et al., 2020) to 164 (Tuominen et al., 2017) and family samples ranged from 28 families (Morrison et al., 2013) to 171 families (Ha et al., 2021). The interventions that described child samples, but not parent samples ranged from 150 children (Boutelle et al., 2017) to 251 children (Maddison et al., 2014).

The parent samples were predominately female participants with 9 parent samples (60%) and 7 child samples (46.7%) being majority female; the only exceptions being the father-focused interventions. Maddison et al. (2014), Schoeppe et al. (2020), and Centis et al. (2012) did not specify details of the parent samples and Schoeppe et al. (2020) and Gunawardena et al. (2016) did not specify details of the child samples.

While the parent samples were primarily female, only 5 (33.3%) had samples that were intended to be gender-based (Barnes et al., 2015; Gunawardena et al., 2016; Morgan et al., 2011, 2014, 2019; Tuominen et al., 2016, 2017, 2018, 2020).

Delivery and Format

Since each article describes a different iteration of each intervention, such as pilot, feasibility, and full trials, the results of the duration of each intervention are discussed by article

(*n*=20), not intervention (*n*=15). The duration of the interventions was quite evenly distributed with 9 articles describing an intervention lasting 8 weeks or less (45%) and 11 articles describing an intervention lasting over 8 weeks (55%) (Table 1). The shortest intervention was the "Moving Sound" pilot study (Tuominen et al., 2016) at 3 weeks duration and the longest was Gunawardena et al. (2016)'s maternal well-being study lasting 12 months.

A large portion of the 15 interventions used a workshop or education session format (*n*=10, 66.7%). Educational sessions were parent-only (Jago et al., 2013; Morgan et al., 20211, 2014; Raynor et al., 2012), parent-child (Barnes et al., 2015; Boutelle et al., 2017, 2021; Ha et al., 2021; Morgan et al., 2011, 2014, 2019), child only (Centis et al., 2012; Gunawardena et al., 2016), or virtual (Karmali et al., 2020; Maddison et al., 2014; Schoeppe et al., 2020). Other delivery methods included home behavior modifications such as encouragement of increasing activity with the family dog (Morrison et al., 2013), using a movement-to-video program (Tuominen et al., 2016, 2017, 2018, 2020), and encouragement of increasing daily step count (Holm et al., 2012). Two interventions had one sole initial session, which kickstarted the program, and there was little follow-up contact (Maddison et al., 2014; Morrison et al., 2013).

Education sessions lasted anywhere from 20-30 minutes (Karmali et al., 2020) to two hours (Jago et al., 2013), but the most common duration was 90 minutes (*n*=4, 26.7%). The shortest delivery was via the movement-to-video program, where the encouraged program lasted 10 minutes, but participants were permitted to do multiple bouts for a longer duration (Tuominen et al., 2016, 2017, 2018, 2020).

Technology was a principal component of approximately a quarter of the interventions (*n*=4, 26.7%). Interventions used video programs (Tuominen et al., 2016, 2017, 2018, 2020), a

mobile app and text messages (Schoeppe et al., 2020), study websites (Maddison et al., 2014), and online education modules (Karmali et al., 2020).

Design

Thirteen of the fifteen interventions (86.7%) were randomized trials, and 11 (73.3%) were randomized controlled trials. The remaining non-randomized trials included a cluster-controlled trial (Centis et al., 2012) and a feasibility trial with pre- and post-intervention measures (Schoeppe et al., 2020). Out of the randomized controlled trials, four (36.3%) utilized a waitlist control design and six (54.5%) utilized a true control group with no intervention provided. There was one intervention that used a modified control group; Maddison et al., (2014) essentially used a waitlist control group, but the control group had access to the same website that the intervention group used during the intervention period.

Setting

Interventions were from around the world, with most coming from North America (*n*=5), Australia or New Zealand (*n*=5), and Europe (*n*=4).

Almost half of the interventions (*n*=7, 46.7%) used a home setting. Home-based interventions tended to have less in-person contacts and use more technology in their delivery. The second-most frequent setting used was the school (*n*=5, 29.4%). These included after-school programs such as the ones conducted by Barnes et al. (2015), Ha et al. (2021), and Morgan et al. (2014). Three interventions used a community setting (Morgan et al., 2011, 2019; Jago et al., 2013). These interventions were held at a central location that the families were unaffiliated with such as a community center or research center. While each of the community interventions promoted a home component of taking what they learned home and putting it into practice, they were not considered home-based interventions due to the constant in-person contact of the

research team via educational sessions. Community-based interventions tended to use theory and play to guide the programs.

The remaining setting seen in the eligible interventions is the clinic. These were determined based on recruitment and location of educational/parental sessions. Both interventions recruited children and their parents based on child overweight or obesity status (Boutelle et al., 2017, 2021; Raynor et al., 2012). The records detailing both interventions described randomized controlled trials that compared certain types of family based behavioral weight loss programs with others.

Theories

Most interventions were theory-driven (*n*=10, 66.7%) with the most commonly cited theories being Self-Determination Theory (*n*=4) and Social Cognitive Theory (*n*=4). Other theories include Behavioral Economics Theory and Family Systems Theory. Gunawardena et al. (2016) used a conceptual framework that didn't have an explicit name, and Morrison et al. (2013) stated the intervention was theory-driven but did not describe the framework or use a name.

Outcomes and Results

Table 2 contains abstracted data related to the primary outcomes of each intervention and how they are measured, if there was a focus on play, and the results of the intervention.

Primary Outcomes

Over half of the interventions had primary outcomes that were focused on the child (*n*=8, 53.3%). The remaining 7 interventions had primary outcomes focused on the dyad (*n*=5, 33.3%; Holm et al., 2012; Karmali et al., 2020; Morgan et al., 2019; Schoeppe et al., 2020; Tuominen et al., 2016, 2017, 2018, 2020) or the parent (*n*=2, 13.3%; Gunawardena et al., 2016; Morgan et al.,

2011, 2014). Most interventions (*n*=10, 66.6%) focused on improving PA in the participants, while a third of the interventions (*n*=5) had primary outcomes that focused on weight status.

PA Measures

Child self-report measures occurred in 8 interventions (53.3%) and included diaries or logs (Holm et al., 2016), questionnaires (Maddison et al., 2014; Morgan et al., 2014; Raynor et al., 2012), and parent report (Centis et al., 2012; Schoeppe et al., 2020; Tuominen et al., 2016, 2017, 2018, 2020). The questionnaires included a Previous Day Physical Activity Recall ("PDPAR"; Raynor et al., 2012), a Multimedia Activity Recall for Children and Adolescents ("MARCA"; Maddison et al., 2014), and a Children's Leisure activity Study Survey ("CLASS"; Morgan et al., 2014). The MARCA and PDPAR are reliable measures of PA and have been validated in youth (Ridley et al., 2006; Weston et al., 1997). The CLASS was reported to be a reliable measure of the frequency, type, and duration of child PA (Telford et al., 2004).

Parent self-report measures were more common than child self-report occurring in 11 interventions (73.3%). They also included diaries or logs (Holm et al., 2012; Morgan et al., 2011, 2014, 2019; Tuominen et al., 2016, 2017, 2018, 2020), interview (Centis et al., 2012), and questionnaires. The questionnaires included a Previous Day Physical Activity Recall (Raynor et al., 2012), a modified sitting questionnaire (Morgan et al., 2014), a modified Godin Leisure-Time Exercise Questionnaire (Barnes et al., 2015), and the International Physical Activity Questionnaire (Gunawardena et al., 2016; Karmali et al., 2020; Maddison et al., 2014).

Objective forms of PA measures were also used. Accelerometers were used to measure child PA in most interventions (*n*=8, 53.3%) (Barnes, et al., 2015; Boutelle et al., 2017, 2021; Ha et al., 2021; Jago et al., 2013; Morrison et al., 2013; Schoeppe et al., 2020; Tuominen et al., 2016, 2017, 2018, 2020) and pedometers were used to measure child PA in four interventions

(26.7%) (Holm et al., 2012; Karmali et al., 2020; Morgan et al., 2011, 2014, 2019). Accelerometers were generally used to measure PA intensity (MVPA, METs, etc.) and pedometers were used to measure a change in activity level by assessing differences in step counts pre- and post-intervention.

In parents, accelerometers were used to measure parent PA in 7 interventions (46.7%) (Barnes et al. 2015; Boutelle et al., 2017, 2021; Ha et al., 2021; Jago et al., 2013; Morrison et al., 2013; Schoeppe et al., 2020; & Tuominen et al., 2016, 2017, 2018, 2020) and pedometers were used in 5 interventions (33.3%) (Gunawardena et al., 2016; Holm et al., 2012; Karmali et al., 2020; & Morgan et al., 2011, 2014, 2019).

Play

Out of the 20 articles, 12 mentioned using "play," "enjoyment," or "fun" as an aspect of the intervention or used it as a method to recruit participants. Out of the 12 articles that used play, 8 (66.7%) were considered by the authors to be effective interventions on improving PA in parents or children. This is compared to four (out of 8, 50%) that did not use play and were found to be effective. The effective, playful interventions used education sessions for parents targeting fun, cophysical activities (Barnes et al., 2015; Morgan et al., 2011, 2014, 2019), a "fun" child-specific activity tracker (Schoeppe et al., 2020), a measure of enjoyment of the intervention (Tuominen et al., 2018, 2020), and a tagline of "less stress, more fun in family life" in recruitment and intervention materials and sessions focused on fun in PA (Jago et al., 2013). The playful-effective interventions also tended to be shorter (6 weeks to 3 months) and have primary outcomes focused on PA or on the parent instead of the child. All playful-effective interventions were theory-based and had program names.

Effectiveness

Seven of the interventions (46.7%) presented evidence of a statistically significant intervention effect on parent and/or child PA (Barnes et al., 2015; Centis et al., 2012; Jago et al., 2013; Gunawardena et al., 2016; Morgan et al., 2011, 2014, 2019; Schoeppe et al., 2020). The "Moving Sound" intervention had mixed effects: the pilot study showed success (Tuominen et al., 2016), but did not see any differences within groups or over time in the larger trial (Tuominen et al., 2017). Secondary analyses of the larger trial showed that children who had a mother with a musical background (Tuominen et al., 2018) and whose mothers enjoyed the movement to video intervention (Tuominen et al., 2020) significantly improved PA after the intervention.

To further assess effectiveness of the interventions, percent change was calculated to compare if improvements in PA levels were achieved post-intervention compared to baseline levels (Table 3). Of the interventions that compared the intervention group to a control or comparison group, all saw at least some improvement in either parent or child PA. Among the interventions that compared to a baseline instead of a comparison group, the one that incorporated play (Schoeppe et al., 2020) saw much greater improvements in PA levels in both children and adults compared to those that did not (Holm et al., 2012, Raynor et al., 2012).

What is currently known about parent-child PA interventions? Both playful and nonplayful interventions showed some improvements in PA outcomes in children and adults that were reviewed in this synthesis. Of the 15 interventions, most were randomized controlled trials, used play in some capacity, were theory-based, and used a workshop or educational session format. While not the majority, a larger portion of the interventions also recruited/measured families and were set in the home as opposed to a school, clinic, or community setting. Overall,

sample sizes in the interventions were not large, had a variety of PA measures and delivery formats, and lasted anywhere from 3 weeks to a year. When looking solely at length, there was no difference between shorter or longer interventions. There were 8 ineffective interventions lasting 8 weeks or less and 8 effective interventions lasting 8 weeks or less. There were 4 ineffective interventions lasting over 8 weeks and 4 effective interventions lasting over 8 weeks (Table 1).

When looking at delivery format, interventions with educational sessions were more often considered effective than ineffective (*n*=7 effective with educational sessions and *n*=4 ineffective interventions with educational sessions). While educational sessions were a frequent intervention delivery (*n*=11, 73.3%), there were also other effective delivery formats: text messages and child friendly activity trackers worked well for the "Step it Up Family" trial (Schoeppe et al., 2020) and setting a goal to increase steps by 2000/day was effective for "America on the Move" (Holm et al., 2012).

Home-based interventions were the most frequent setting (*n*=7, 46.7%) and there seemed to be no effect on effectiveness with three showing evidence of statistical significance in improving PA and three showing no evidence of effectiveness. School-based interventions were the second-most frequent cited setting (*n*=5, 33.3%). This setting did have more favorable outcomes with four out of the five interventions showing evidence of effectiveness (Barnes et al., 2015; Centis et al., 2012, Gunawardena et al., 2016; Morgan, et al., 2014).

All three community-based interventions were considered effective by the authors (Jago et al., 2013; Morgan et al., 2011, 2019), and in contrast, neither of the two clinic-based interventions were considered effective (Boutelle et al., 2017, 2021; Raynor et al., 2012).

When looking at all articles (*n*=20), 8 are effective and used a theory-driven intervention (40%) compared to 4 theory-driven interventions that were not considered effective (20%). Two of the ineffective theory-driven interventions used Behavioral Economics Theory.

Does play influence effectiveness of the intervention? The effective playful interventions (*n*=8) used education sessions (Barnes et al., 2015; Jago et al., 2013; Morgan et al., 2011, 2014, 2019), movement-to-video program (Tuominen et al., 2018, 2020), motivational text messages and child-friendly trackers (Schoeppe et al., 2020). These interventions tended to have set expectations and programming, and all lasted between 6 and 8 sessions, or no longer than 3 months. All effective playful interventions used a theory-driven approach, with all citing either Social Determination Theory or Social Cognitive Theory. There was no commonality between setting, but most did use an educational session format for delivery, which may indicate that the frequent promotion of play/fun may lead to more effective interventions.

Discussion

This review has examined characteristics and outcomes of parent-child physical activity or active play interventions related to improving physical activity levels in the parent and/or child and what role including play may have on PA outcomes. While there are plentiful interventions on improving PA in adults or in children, it is unknown if play can be used to improve PA in a family or dyadic intervention. The interventions used in this synthesis provide evidence of parent-child interventions that measured PA at the parent and/or both parent-child level and may or may not have used play or theory to drive the intervention.

Seven of the fifteen interventions showed favorable PA outcomes in parents and/or children, indicating that dyadic interventions have mixed results in terms of effectiveness. Of those seven, five used enjoyment or play in their methodology. Results of the synthesis show that

theory-driven and playful interventions are more likely to be effective in improving PA in parents and/or children in parent-child PA interventions. Using fun, playful, and evidence-based theories can make for interventions that are enjoyable for families and can therefore improve physical activity interventions.

Previous literature suggests that physical activity interventions should be designed with participant enjoyment in mind to motivate adherence to the programming (Hagberg, Lindahl, Nyberg & Hellénius, 2009; Remmers, Sleddens, Kremers & Thijs, 2015). This review supports that interventions which included a "playful" aspect in the recruitment or design of the PA program saw more favorable outcomes than those that did not. There are several behavioral change theories that allude to enjoyment improving health behaviors: theory of planned behavior, social cognitive theory, health belief model, social ecological model, and self-determination theory. The interventions in this review that used theory and enjoyment were guided by Self-Determination Theory, Social Cognitive Theory, Family Systems Theory and Behavioral Economics Theory.

This review suggests that using a playful approach in a theory- and family-based physical activity intervention improves PA in parent-child dyads. Regarding theory and family, this is supported by Mannocci et al. (2020), who found that the most promising child and youth PA interventions were those that used behavioral change theory in the design and involved both parents and children. While play has been studied extensively to increase PA in children, including it as a tool in dyadic or familial interventions is still novel. Current PA policies among agencies such as the American Academy of Pediatrics or the World Health Organization still lack specifics about family and play in children's PA, but others such as the Centers for Disease Control and Prevention may provide guidance to parents regarding encouraging play to reduce

sedentary behavior and make PA more fun (Foster et al., 2018). Even among the organizations that promote play to improve PA in children, they focus on younger children (less than 6 years old) and do not mention that it may improve parents' PA as well (Foster et al., 2018).

A review from 2007 found that even though parental support has a strong correlation with child PA in the literature, there were few interventions that involved a family component, and it was not possible to assess if evidence of effectiveness of parental involvement being strong in influencing child PA (van Sluijs et al., 2007). Because the current review only assessed interventions that had a high level of parental involvement, it is not possible to answer the question of effectiveness of parental involvement in child PA interventions, but the low number of interventions in the current review may indicate that this may still not be known almost two decades later.

This review also suggests that delivery is important in dyadic PA interventions. Longer, more intensive interventions appeared to have a stronger intervention effect on PA levels, but it is not possible to determine the relationship in this review because adherence or attendance was not abstracted or evaluated across interventions. Recent reviews have also found that the most promising child PA interventions are longer in duration (Alalawi et al., 2024; Mannocci et al., 2020). In the current review, there was no consensus among settings or delivery for effectiveness, but Maitland et al. (2013) suggests that the home environment may be a particularly important environment to promote play, especially including social and technological aspects. While they suggest that a parent has a role in adjusting the home environment to be more play- and PA-friendly, they do not suggest that a parent should participate in active play with the child to influence child PA (Maitland et al., 2013). Frequent exposure of the intervention to the participants, regardless of in-person educational sessions or

text messages, also appears to be related to the effectiveness of the intervention. This coincides with the literature on behavior change interventions regarding cues and repetition to establish and maintain a health behavior change (Wood & Neal, 2016).

Strengths and Limitations

This review surveyed over 1000 articles across three major databases to identify interventions that aimed to improve PA in families with children aged 6-10 years using both playful and non-playful methods. Systematically assessing the characteristics of the included interventions provide insights on the methodology of effective and ineffective family-based PA interventions. While play has increasingly been used in child PA interventions, comparing interventions that do and do not use play allows for additional exploration in methodology that works for children. Additionally, this review adds a further level of exploring the less frequent availability of dyadic parent-child PA interventions.

While the current review examined 15 interventions, this was across 20 articles which provides limited ability to conclude effectiveness as multiple articles of one intervention introduces variation. As previously mentioned, another limitation also includes the lack of analysis of attendance or adherence of an intervention to determine fidelity to the intended program and how that may or may not have influenced results. Additionally, the search and abstraction processes were conducted by the first author alone as part of a dissertation and while a second individual did confirm a subsample of the search results, it is possible that additional reviewers during the abstraction and literature assessment could have strengthened this review.

Conclusion

The current review adds to the literature by providing support for family- and theory-based playful interventions for children that intend to promote physical activity in young school-

aged children (6-10 years old). By employing subjectively fun, age-appropriate tactics, both parents and children are likely to remain engaged in an intervention to build on a healthier lifestyle. The interaction effect of children and play on parent physical activity should be further studied to determine whether adults also benefit from child support and play the same way children benefit from parental support.

Acknowledgements

The authors would like to acknowledge Beth Auten for library assistance in preparing for the review and J.P. Barfield for the coordination and support provided throughout the dissemination process.

Funding Source

The authors did not receive support from any organization for the submitted work.

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Table 1. Characteristics of Parent-Child Physical Activity Intervention Studies (*n*=15)

First Author & Year	Sample	Delivery and Format	Design	Setting	Theory
Barnes et al., 2015 *Mothers and Daughters Exercising for Life (MADE4Life)*	*N*=40 mothers and their daughters aged 5-12 (*N*=48) Parent: Mothers only, mean age 39.1 ± 4.8 years Child: Daughters only, mean age 8.5 ± 1.7 years	Separated education sessions held after school followed by a dyadic PA session each week. Sessions focused on fun, active games, health, and fitness. 8 sessions lasting 90 minutes each; 8 weeks duration.	Pilot RCT. Mothers stratified by BMI and randomized to INT or 6-month waitlist CON	After-School Australia	Social Cognitive Theory
Boutelle et al., 2017 Boutelle et al., 2021 *Family, Responsibility, Education, Support and Health (FRESH)*	2017: *N*=150 children Parent: 87.3% female; mean age 42.9 Child: 66.4% female, mean age 10.4 years 2021: *N*=137 dyads Parent: 87.1% female, mean age 42.9 ± 6.5 years Child: 64.1% female, mean age 10.4 ± 1.3 years	All: Family-based sessions focused on providing education on behavior modification strategies, parenting skill, and health information. 20 sessions lasting 1 hour each; 6 months duration.	2017: Randomized clinical noninferiority trial evaluating family-based or parent-based treatment of childhood obesity 2021: Within treatment group analysis of randomized clinical trial data	Clinic USA	No mention of theory
Centis et al., 2012	*N*=209 children Parent: Not specified Child: INT: 51.5% female, mean age 9.33 ± 0.29 years; CON: 52.8% female, mean age 9.36 ± 0.35 years	Educational sessions, motivational contacts focusing on benefits of healthy diet and PA. 4 meetings with weekly phone calls during first 4 months; 8 months duration.	Cluster-controlled trial	School/Home Italy	No mention of theory
Gunawardena et al., 2016	*N*=261 mothers Parent: Mothers only, INT: mean age 37.5 ± 5.6 years; CON: 38.5 ± 5.9 years Child: Grade 8 students	Health promotion facilitators led education series to students focused on health and well-being of their mothers. Biweekly, then once in 3 or 4 weeks after appx. 5 months; 12 months duration.	Cluster RCT	School Sri Lanka	Conceptual framework that participants must take control over factors that govern their lives instead of being

					pre-determined by outsiders
Ha et al., 2021 *Active 1 + Fun*	*N*=171 families Parent: 70% female Child: 40% female, mean age: 10 years	Dyadic 30 min. education workshops + 60-minute activity sessions. 10 sessions lasting 90 minutes each; 9-month duration.	RCT with waitlist control	After-school Hong Kong	Self-Determination Theory
Holm et al., 2012 *America on the Move*	*N*=83 families Parent: 74.6% female Child: 53% female, mean age: 11.06 ± 2.15 years	Encouraged to increase steps by 2000/day. 6 months duration.	RCT	Home USA	No mention of theory
Jago et al., 2013 *Teamplay*	*N*=48 parents Parent: INT: 100% female; CON: 95.7% female Child: INT: 61.9% female, mean age 6.6 ± 1.3 years; CON: 68.8% female, mean age 8.0 ± 1.8 years	Parent only sessions providing education on PA, active play, screen time, and parenting. 8 sessions lasting 2 hours each; 8 weeks duration.	Two-arm individualized feasibility RCT	Community Center UK	Self Determination Theory
Karmali et al., 2020	*N*=50 dyads Parent: 94% female, mean age 37 ± 6.7 years Child: 64% female, mean age 6.8 ± 2.8 years	Online education modules/webinars on PA and lifestyle behaviors plus phone coaching intervention compared to education only control group. 6 modules lasting 20-30 minutes each, 9 20–30-minute phone coaching sessions; 3 months duration.	RCT	Home Canada	No mention of theory
Maddison et al., 2014 *Screen-Time Weight-loss Intervention Targeting Children at Home (SWITCH)*	*N*=251 children Parent: Primary caregiver Child: INT: 43% female, mean age 11.2 years; CON: 44% female, mean age 11.3 years	One face-to-face meeting to educate on strategies to reduce screen time. TV monitoring devices, online support via a website, and monthly newsletters used. 1 info session and various website views; 20 weeks duration.	RCT where CON had access to website, but given other components after follow-up of INT	Home New Zealand	Social Cognitive Theory, Behavioral Economics Theory
Morgan et al., 2011 Morgan et al., 2014 *Healthy Dads, Healthy Kids*	2011: *N*=53 fathers and their children (*N*=71) Parent: Fathers only, mean age 40.6 ± 7.1 years	Parent-only group sessions (3 included children) focused on providing opportunities for PA. Father/child	2011: RCT with waitlist control	2011: Research Center	Social Cognitive Theory, Family Systems Theory

	Child: 46.5% female, mean age 8.2 ± 2.0 years 2014: *N*=93 fathers and their children (*N*=132) Parent: Fathers only, mean age 40.3 ± 5.3 years Child: 45% female, mean age 8.1 ± 2.1 years	sessions focused on rough-tumble play and active play. 2011: 8 sessions lasting 75 minutes each; 3 months duration. 2014: 7 sessions lasting 90 minutes each, 7 weeks duration (follow-up at 14 weeks).	2014: RCT with waitlist control	2014: After-school Australia	
Morgan et al., 2019 *Dads And Daughters Exercising and Empowered (DADEE)*	*N*=115 fathers with their daughters (*N*=153) Parent: Male only, 18–65-year-old Child: Female only, 4-12 years old	Education sessions on importance of PA and engaging in co-PA. 8 sessions lasting 90 minutes each; 8 weeks duration.	RCT with waitlist control	Research Center Australia	Self Determination Theory
Morrison et al., 2013 *Children, Parents and Pets Exercising Together (CPET)*	*N*=28 families Parent: 82% Female, mean age 44.8 years Child: 67% female, mean age 10.9 years	Modification of family environment, provide resources on dog walking routes and active play with pets. 1 home visit; 10 weeks duration.	Exploratory RCT	Home UK	States theory driven but no theory named
Raynor et al., 2012 *Growth Monitoring*	*N*=84 parents Parent: 90.1% female, mean age 38.0 ± 5.7 years Child: 60.5% female, mean age 7.1 ± 1.5 years	Parent-only small group sessions focused on education, goal setting, and parenting. 8 sessions lasting 45 minutes each; 6 months total duration.	Randomized trial comparing INT, INT + Traditional, and INT + Substitutes methods of behavior modification	Clinic USA	Behavioral Economics Theory
Schoeppe, et al., 2020 *Step it Up Family*	*N*= 40 families (58 children, 39 mothers, 33 fathers) Parent: Mothers and fathers Child: 6–10-year-olds	Mobile app and text messages sent to parents providing resources, motivation, challenges, and leaderboard. Text messages sent 3x/week; 6 weeks duration.	Feasibility trial with pre-post intervention measures	Home Australia	Social Cognitive Theory, Social Determination Theory

Table 1 cont.

Tuominen et al., 2016 Tuominen et al., 2017 Tuominen et al., 2018 Tuominen et al., 2020 *Moving Sound*	2016: *N*=23 Dyads Parent: Mothers only, mean ages: INT Group 38.7 ± 4.3 years, CON group 38.9 ± 5.8 years Child: Not specified 2017: *N*=164 Dyads Parent: Mothers only, mean ages: INT: 37.0 ± 4.7 years, CON: 37.9 ± 5.0 years Child: INT: 44.6% female, mean age 6.5 ± 0.5 years. CON: 54.9% female, mean age 6.5 ± 0.5 years 2018: *N*=71 Dyads Parent: Mothers only, mean ages: Music: 38.2 ± 5.4, Comparison: 36.1 ± 4.0 years Child: Music: 60% female, mean age 6.7 ± 0.4, Comparison: 41.3% female, mean age 6.5 ± 0.5 years 2020: *N*=108 Dyads Parent: Mothers only, mean ages: INT: 36.4 ± 4.6 years; CON: 38.2 ± 5.1 years Child: INT: 46% female, mean age 6.6 ± 0.5 years; CON: 58.6% female, mean age 6.65 ± 0.5 years	Movement to music video program meant to motivate mother and child to exercise together to beat of music. Recommended to use program every other day. Videos lasted 10 minutes but could be used alone or consecutively for more time. 2016: 3 weeks duration. 2017: 8 weeks duration. 2018: 8 weeks duration. 2020: 8 weeks duration.	2016: Pilot RCT 2017: RCT 2018: Secondary analysis of 2017 RCT data, analyzing INT mothers who have musical background vs. no musical background 2020: Secondary analysis of 2017 RCT data, analyzing INT & CON mothers with accelerometer data that answered enjoyment questions	Home Finland	Self-Determination Theory (only explicitly stated in 2020 paper)

(INT=intervention; CON=control; RCT= randomized controlled trial)

Table 2. Outcomes & Measures in Parent-Child Physical Activity Intervention Studies (*n*=15)

First Author & Year	Primary Outcome	PA Measure	Focus on Play	Results
Barnes et al., 2015 *Mothers and Daughters Exercising for Life (MADE4Life)*	Daughters' MVPA	Child: MVPA measured by accelerometer (GT3X & GT3X+) using CPM and established cutoffs to determine time in MVPA and percentage in other intensities* Parent: MVPA measured by accelerometer (GT3X & GT3X+) & METs measured by self-report (modified Godin Leisure-Time Exercise Questionnaire*).	Activities were based on fun, interactive games and fitness activities encouraging reciprocal reinforcement between mothers and daughters.	No significant intervention effect (d=-.03) for the primary outcome of daughter time spent in MVPA. Intervention mothers increased their %MVPA by 0.4% at postintervention compared with the control group who decreased by 0.1%. A significant intervention effect was found for mothers %VPA (p=0.04, d=0.25), with the overall group by time effect significant (p= 0.04) with the mothers in the MADE4Life group increasing their %VPA (+0.22%, 95% CI; 0.05, 0.39) compared with the control group (+0.04% 95% CI; -0.15, 0.22).
Boutelle et al., 2017 Boutelle et al., 2021 *Family, Responsibility, Education, Support and Health (FRESH)*	Child weight loss (BMI)	Child: Time spent in MVPA measured by accelerometers (ActiGraph GT1M) using intensity cutoffs* Parent: Time spent in MVPA measured by accelerometers (ActiGraph GT1M) using intensity cutoffs*	N/A	2017: No significant differences between groups in MVPA among children (p=0.90) or adults (p=0.37) 2021: Secondary analysis of RCT: no significant associations between child weight-loss rates and physical activity (p>0.1)
Centis et al., 2012	Change in child weight (BMI z-score)	Child: parent report (detailed behavioral interview) Parent: self-report (detailed behavioral interview)	N/A	Time spent in outdoor activities increased over time in the children in the intervention group (p<0.001) and at a significantly higher rate than children in the control group (p=0.0155). Only baseline parent PA data provided.
Gunawardena et al., 2016	Mother's weight and BMI, PA levels, and diet	Child: PA not measured Parent: METs measured by self-report (International Physical Activity Questionnaire long form*) & step counts measured by pedometers (Power-Walker EX-510)	N/A	Intervention group had significantly greater odds of engaging in adequate PA than control group (OR: 3.25, 95% CI 1.87-5.62). Total daily step count was significantly improved between groups over time (p<0.0001).

Ha et al., 2021 *Active 1 + Fun*	Child MVPA	Child: MVPA measured by accelerometry (ActiGraph wGT3x-BT) using cutpoints to determine intensity* Parent: MVPA and co-PA measured by accelerometry (ActiGraph wGT3X-BT) using cutpoints to determine intensity* and proximity feature of accelerometers	Based on Self-Determination Theory constructs, sessions were meant to be supportive, active, autonomous, fair, and enjoyable.	There were no significant differences found over time between the intervention and control groups (p>0.05), but there were significant differences between groups in co-physical activity at baseline and immediately post intervention (p<0.05) and higher child MVPA following the intervention (p<0.05).
Holm et al., 2012 *America on the Move*	Parent and child step counts	Child: Step counts measured by pedometers (Accusplit AE120*) and steps logged daily Parent: Step counts measured by pedometers (Accusplit AE120*) and steps logged daily	N/A	Child change in PA is predicted by parents' change in steps on the current day (p<0.0001), the prior day (p=0.02), and averaged across the prior 7 days (p=0.005). This paper analyzes the intervention arm of a previous study and therefore does not have data on intervention effects.
Jago et al., 2013 *Teamplay*	Feasibility of collecting accelerometer data and children's change in MVPA following intervention	Child: MVPA measured by accelerometer (Actigraph GT1M) using cutpoints to identify mean minutes of MVPA* Parent: MVPA measured by accelerometer (Actigraph GT1M) using cutpoints to identify mean minutes of MVPA*	Tag line: "less stress, more fun in family life" and intervention materials focusing on fun in PA	Child weekend MVPA, parent weekend MVPA, and parent weekday MVPA increased in intervention group over time compared to control group (p values not reported). The improvements were not maintained 8 weeks post-intervention.
Karmali et al., 2020	PA and diet of dyads, parental motivation, parent body composition	Child: PA measured by pedometers Parent: PA measured by pedometers & self-report questionnaire (International Physical Activity Questionnaire*)	Parent interviews on impact of intervention gathered data on enjoyment.	Parents reported that children enjoyed tracking steps and competition with parents. The main effects model demonstrated no significant difference from the null model over time on parent or child step count, parent PA or parent sedentary time measured by IPAQ. The interaction models also demonstrated no significant difference from the null model, suggesting that there was no effect of the intervention over time on any parent or child outcomes.
Maddison et al., 2014	Change in child weight (BMI)	Child: Time spent in various PA intensities (METs) was measured	Enjoyment was measured using the	No significant differences were found between groups in PA (p>0.05) or enjoyment (p=0.82).

Screen-Time Weight-loss Intervention Targeting Children at Home (SWITCH)		by self-report (Multimedia Activity Recall for Children and Adolescents*) Parents: MET-minutes/week was measured by self-report (International Physical Activity Questionnaire long form*)	Physical Activity Enjoyment Scale* modified for adolescents	
Morgan et al., 2011 Morgan et al., 2014 *Healthy Dads, Healthy Kids*	Fathers' weight	Child: PA measured by pedometers (Yamax SW700*) and steps logged daily. Sedentary behavior also measured in 2014 using CLASS questionnaire* Parent: PA measured by pedometers (Yamax SW700*) and steps logged daily. Sedentary also measured in 2014 using modified Sitting Questionnaire*	PA sessions included focus areas of rough and tumble play and fun, active games. Vigorous intensity active play encouraged as method to develop physical fitness.	Two papers describing the same intervention on two different cohorts. 2011: Improvement seen in steps/day in fathers (p=0.002) and children (p<0.001) from pre- to post-intervention 2014: Significant improvements in mean steps/day in fathers (p=0.04) and children (p=0.01) in intervention group over time
Morgan et al., 2019 *Dads And Daughters Exercising and Empowered (DADEE)*	Fathers' and daughter's PA levels	Child: PA levels measured by pedometers (Yamax SW200*) and steps logged daily Parent: PA levels measured by pedometers (Yamax SW200*) and steps logged daily	Education sessions and resources provided meant to engage fathers and daughters in fun, co-physical activities targeting rough and tumble play, among other types of PA.	Fathers' (p<0.001) and daughters' (p=0.02) physical activity levels were significantly improved after intervention and maintained or increased 9 months post-intervention (p=0.03 daughters; p<0.001 fathers) compared to control group. Process outcomes measures shows that fathers had a high level of satisfaction with the program (mean 4.9 (0.3) out of 1-5 scale, 5=excellent).
Morrison et al., 2013 *Children, Parents and Pets Exercising Together (CPET)*	Child volume of PA	Child: Changes in volume of PA & PA intensity measured by accelerometry (ActiGraph GT3X) counts per minute cutoffs* Parent: Changes in volume of PA & PA intensity measured by accelerometry (ActiGraph GT1M) counts per minute cut offs*	The intervention intended to increase play and PA time in parents/children with their dog.	No significant differences in the number of walks per week or total duration of walks per week. No significant differences in the total volume of PA, amount of time being sedentary or the amount of time in light intensity PA or MVPA for children or their parents. Focus group data shows that children enjoyed the study and getting to play with their dog.
Raynor et al., 2012 *Growth Monitoring*	Child weight loss (BMI)	Child: Leisure time PA measured by parent-report (Previous Day Physical Activity Recall*)	N/A	Two RCTs described in article, only Trial 2 was eligible so only Trial 2 data is displayed here.

		Parent: Leisure time PA measured by self-report (Previous Day Physical Activity Recall*)		No changes were seen in leisure-time PA in child or parent at 0-, 6-, and 12-month postintervention (p>0.05).
Schoeppe, et al., 2020 *Step it Up Family*	PA levels in children and parents	Child: MVPA measured by parent report (CLASS questionnaire*) & step count and active minutes measured by Garmin Vivofit Jr. Parent: MVPA measured by self-report (Active Australia Survey*) & step count and active minutes measured by Garmin Vivofit 3*	Used a "fun" child-specific activity tracker to engage children	Children, mothers, and fathers significantly increased PA levels (p<0.001).
Tuominen et al., 2016 Tuominen et al., 2017 Tuominen et al., 2018 Tuominen et al., 2020 *Moving Sound*	2016, 2017 & 2018: Sedentary behavior and PA of mothers and their children 2020: Mothers' enjoyment of performing exercises with their child	Child: METs and MVPA measured by accelerometer (Hookie AM20*) and paired with parent-report diaries Parent: METs and MPVA measured by accelerometers (Hookie AM20*) and paired with self-report diaries 2020: Mothers' enjoyment was measured by the Finnish version of the Enjoyment in Sport (EIS) questionnaire, modified for use with a child	2016: N/A 2017: N/A 2018: Enjoyment was defined as children and their mothers having fun with the video program. The data for enjoyment was collected from questionnaires by classifying free comments of the children and their mothers. 2020: Mothers' enjoyment was examined using a modified Enjoyment in Sport questionnaire	2016: Pilot. Less sedentary time was observed in mothers and children in the INT group. Significant improvements in light PA (p<0.05) and MVPA (p=0.03) were seen in the INT children compared to CON over time. No significant differences in PA for mothers. 2017: No significant differences within groups or between groups over time in sedentary behavior or PA in mothers or children. 2018: Subsample of RCT participants comparing mothers who have musical background vs. those who don't. Significant improvements were found in child light PA (p=0.014) in the musical background group over time. Mother light PA (p=0.021) and mother overall PA (p=0.004) significantly increased in the non-musical background group over time. Enjoyment was measured through questionnaires and found to be higher in the non-musical background group. 2020: Subsample of RCT participants that had acceptable accelerometer measurements and answered questions about enjoyment in questionnaires. Children's light PA levels

				significantly increased over time if the mothers had higher levels of enjoyment (p<0.001). Children with mothers who scored lower in enjoyment increased sedentary behavior over time.

* Indicates the measure was stated by authors or citation to be validated for the population; METs: metabolic equivalents, MVPA: moderate-vigorous physical activity, BMI: body mass index.

Table 3. Percent change of mean or percentage values provided in articles.

		Children		Adults	
	Measures~	**Control**	**Intervention**	**Control**	**Intervention**
Barnes et al., 2015	% Time in SB	-5.74	-2.90	0.36	0.91
MADE4Life	% Time in LPA	4.84	2.14	-0.18	-1.39
	% Time in MPA	0.58	0.63*	-0.19	0.20*
	% Time in VPA	0.36	0.26	0.04	0.22*
	% Time in MVPA	0.96	0.88	-0.14	0.38*
	CPM	111.39	99.23	-7.07	16.75***
Boutelle et al., 2017 Boutelle et al., 2021^ *FRESH*	Time in MVPA (min/day)	-9.77	-7.79*	-15.67	-4.11**
Centis et al., 2012	Time spent outdoors (hr/week)	14.81	59.39***	-	-
Gunawardena et al., 2016	Adequate PA (MET-min/wk ≥3359)	-	-	-30.95	9.84***
	# of daily steps	-	-	-22.99	12.05***
Ha et al., 2021	MVPA (min/day)	16.78	31.86**	17.93	26.82*
Active 1 + Fun	Co-PA (min/day)			1.99	12.08**
Holm et al., 2012	Daily step count	-	17.65	-	-
America on the Move	Mothers' daily steps				19.06
	Fathers' daily steps				9.91
Jago et al., 2013	Weekday MVPA (min/day)	11.32	5.50	3.31	20.10**
Teamplay	Weekend MVPA (min/day)	17.06	31.51**	-23.24	38.54***
Karmali et al., 2020	# of weekly steps	-5.61	63.67***	17.21	36.34**
	IPAQ Sitting Time (min/day)	-	-	-7.95	-8.33*
	IPAQ MET (min/week)	-	-	4.93	44.02***
Maddison et al., 2014	Time in SB (min/day)	-3.39	-5.45*	^	^
SWITCH	Time in LPA (min/day)	21.05	18.35		
	Time in MPA (min/day)	-24.72	0***		
	Time in VPA (min/day)	-15.91	3.23**		
	Time in MVPA (min/day)	-18.06	0.69**		
Morgan et al., 2011	Daily step count (2011)	-6.88	4.16**	-0.49	25.56***
Morgan et al., 2014	Daily step count (2014)	-1.58	14.26**	11.07	28.79**
Healthy Dads, Healthy Kids	Time in SB (min/day) (2014)	4.23	-5.63*	-	-
Morgan et al., 2019	Daily step count	4.00	12.37*	-5.15	10.23**
DADEE	Fathers' MVPA (min/week)			4.57	42.57***
	Co-PA (days/week)			-10.53	33.33***

Morrison et al., 2013 ***CPET***	% Time in SB % Time in LPA % Time in MVPA CPM	-0.12 -1.20 -3.23 -0.57	-0.25* -0.625* 6.45* 5.18*	-10.2 0.82 6.0 3.68	1.84 -4.45 0 -4.89
Raynor et al., 2012 *Growth Monitoring*	% Time in MVPA – Intervention 1 % Time in MVPA – Intervention 2 % Time in MVPA – Intervention 3		-28.57 -38.34 20.41		76.54 -32.67 -25.95
Schoeppe, et al., 2020 ***Step it Up Family***	Time in MVPA (min/day) Females' time in MVPA (min/day) Males' time in MVPA (min/day)		111.80 115.08 108.42		298.96 321.18 278.19
Tuominen et al., 2016 Tuominen et al., 2017^ Tuominen et al., 2018^ Tuominen et al., 2020^ *Moving Sound*	% Time in SB % Time in LPA % Time in MVPA	6.64 -4.00 -13.95	-7.07** 6.41** 11.54***	0.58 -6.25 6.98	-5.83* 3.24* 10.00*

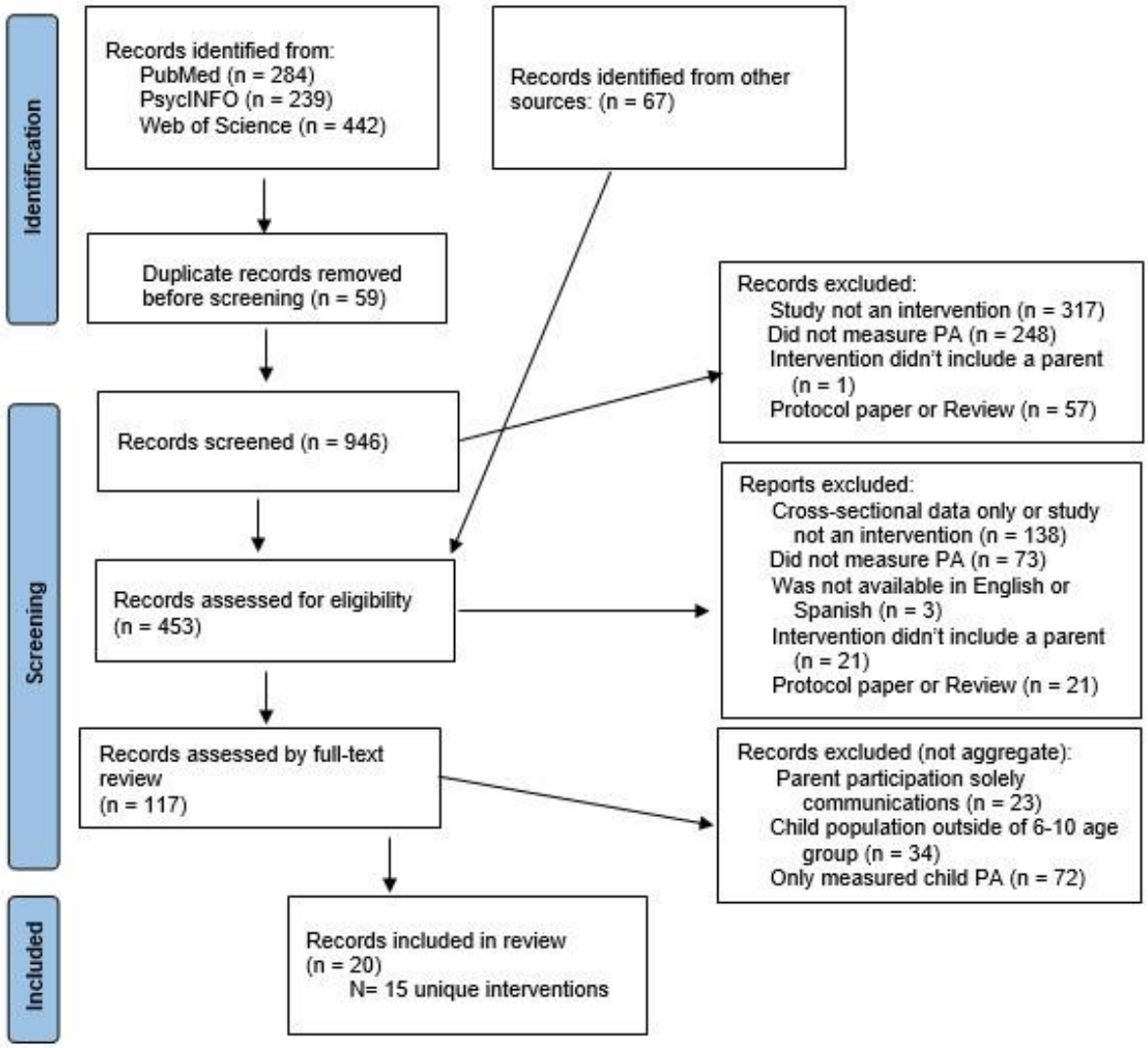
~All values are % change of mean values of immediate post-intervention from baseline unless otherwise indicated. **Bolded** author/year indicates a positive change in either adults' and/or children's PA in the intervention.

*Indicates a greater improvement compared to control group. **Indicates a greater than 10% improvement compared to control group. ***Indicates a greater than 20% improvement compared to control group.

^Indicates the article did not provide mean PA values to be calculated.

(SB: Sedentary Behaviors; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate-vigorous physical activity; CPM: count per minute.)

Figure 1. Article Identification flow diagram



APPENDIX 1.1

Items abstracted for literature synthesis:

1. Title of article
2. First Author
3. Year of publication
4. Country where intervention took place
5. Sample
    a. Overall priority population
    b. Sample size
    c. Child Sex
    d. Child Age
    e. Parent Sex
6. Intervention
    a. Design
    b. Intervention name
    c. Physical activity component
    d. Parent involvement
    e. Primary outcome of interest
    f. Physical activity measurement: Child
    g. Physical activity measurement: Adult
    h. Location/setting
    i. Duration/intensity
    j. Play/fun component
7. Theoretical Framework
8. Results

ARTICLE 2: SMARTPHONE APPS PROMOTING DYADIC PHYSICAL ACTIVITY AND ACTIVE PLAY: A CONTENT ANALYSIS

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Abstract

Background: Adults and children have access to and spend large portions of time on mobile devices leading to an increased risk of physical inactivity. Smartphones and other mobile devices (i.e. tablets) also are vastly used for play and fitness and therefore have the capacity to promote fun physical activity in families such as active play. ***Methods:*** To assess mobile apps available to parents and children regarding play, a content analysis of available smartphone apps was performed of the Apple App Store using two iOS devices, an iPhone and an iPad. Apps were included if they were available in English and/or Spanish; had a price less than or equal to $10/month or had a free trial; had an Age Rating for adults (17+) and/or children older than five; and were not targeted towards a specific group such as users of a local parks department or school system. Apps were excluded if they did not appear to be geared towards children/families or if their descriptions did not mention of "fun," "play," or "games." Apps were downloaded and reviewed for meeting active play criteria and family involvement as well as standard features such as cost, size, and user ratings. ***Results:*** 43 apps met criteria and functioned sufficiently to be reviewed. 86% (*n*=37) of those met active play criteria and 72.1% (*n*=31) included a family/non-solitary component. Only 28 (65.1%) met both active play criteria and included a family/non-solitary component. ***Conclusion:*** Apple's App Store has at least 28 apps that are designed for families to partake in fun physical movement together. Most apps that met inclusion criteria are favorably reviewed and affordable (<$10/month), although they are still primarily designed for solitary users.

Introduction

A lack of physical activity can lead to adverse health consequences such as increased weight, depression, and chronic illness (Booth et al., 2012). In the United States (U.S.), 24.2% of adults in 2020 met guidelines for aerobic and muscle-strengthening activities (Elgaddal et al., 2022) and 20.0% of children met guidelines in 2022 (Physical Activity Alliance, 2024). Physical activity (PA) levels tend to be highest in children and decrease across the lifespan. For children, it is reported that 88% of children 2-5 years old meet PA recommendations, while it is estimated that between 26%-42% of 6–11-year-olds meet PA recommendations and 15% of 12–17-year-olds do (Physical Activity Alliance, 2024). The percentage of adults 18-24 years old who meet both aerobic and muscle-strengthening PA recommendations is 34.0%, 24.1% in 25–64-year-olds, 16.4% in 65–74-year-olds, and 10.2% in adults older than 75 (National Center for Health Statistics, 2018). Additionally, adults with children ("parents") are less active than their childless peers. Among parents, those with young children (less than 6 years old) are less active than those whose children are school-aged (Palomäki et al., 2023).

Due to these trends, research on PA among families or in the parent-child dyad is not lacking. It is known that family support such as modeling or parenting style can influence physical activity for children and adults both in positive and negative ways (Physical Activity Alliance, 2022; Scarapicchia et al., 2017). Physical activity interventions also use family support to improve PA in children, but physical activity as an outcome is not usually measured or reported in the adults that participate in the intervention.

Play, specifically "active play," has increasingly been studied as a means to improve physical activity in children. Active play has been defined as physical activity in a playful context (Pellegrini & Smith, 1998) or more specifically, "a form of gross motor or total body

movement in which young children exert energy in a freely chosen, fun, and unstructured manner" (Truelove 2017). Physical activity interventions, school and community programs, and resources through professional organizations (e.g. Centers for Disease Control and Prevention) often target play to improve physical activity due to its enjoyable nature and to potentially remove negative connotations that might be related with prescribed physical activity such as "exercise" (Burns et al., 2017; Goodyear et al., 2023; Johnstone et al., 2018)

With 90% of the U.S. population having access to a smartphone (Statista, n.d.), phones are becoming a primary source of health information and resource connectivity via web browsing, mobile apps, and telehealth. Studies have found that users of mobile health apps tend to be younger (less than 30-45 years old), educated (more than high school), and health-motivated (Carroll et al., 2017; Paradis et al., 2022). Sixty percent of parents say that their child aged 11 or younger has interacted with a smartphone and over a third report that their child less than 12 years old has their own smartphone (Auxier et al., 2020). There is a market for health apps designed for children, which is likely due to the growing number of children using smartphones and tablets. From 2019 to 2021, the percentage of children ages 8-18 that owned a smartphone rose from 41% to 43% and the percentage that owned a tablet rose from 52% to 57% (Rideout et al., 2022). Health apps designed for children include those that are designed to improve diet, physical activity, and sedentary behavior (Schoeppe et al., 2017). Since they are aimed for children, health apps also double as ones that could be considered for play.

Using technology to keep adults and children entertained is more prevalent now with human interactions declining during and after the COVID-19 pandemic (Michelson et al., 2021; Nawaz et al., 2024), but its popularity in keeping or encouraging physical activity has not been studied as it relates to active play in families. The use of technology for fitness or for family time

will not fade (Hessel & Dworkin, 2018; Sullivan & Lachman, 2017); adults already use streaming services such as YouTube and Peloton for fitness. Learning more about the potential influences of PA in children and adults would expand active play literature and contribute to mobile health and family health literature. This study evaluated the characteristics of smartphone apps that promote child- and family play and/or make PA potentially effective, in increasing active play in families.

To assess mobile apps available to parents and children regarding play, a content analysis of available smartphone apps was performed to ascertain availability and applicability to parent-child dyads (child age 6-10 years old). Content analyses are a useful research technique for making inferences about text, images, and designs to determine context of use and are commonly used to analyze the quality and features of apps that promote PA (Arigo et al., 2020; Krippendorff, 2019). Both text-based material (description of the app's content from the app store) and the content of the app itself were analyzed for its relationship to active play and the level to which parents and children participate in the activity together. While parents of school-age children (6-10 years old) are more likely to meet PA recommendations than parents of younger children (5 years and younger) (Palomäki et al., 2023), school aged children are more familiar with mobile devices (Trott et al., 2022) and are still in the developmental stage to want to play with their parents (Malik & Marwaha, 2023).

Methods

Study Design

This study involved a qualitative content analysis of family active play components contained in apps selected from Apple's App Store. The apps were searched for and coded by the first author using two different Apple devices. While other smartphone operating systems could

house additional relevant apps, Apple iOS has more than half of the United States' smartphone market as of November 2022 with more than 120 million iPhone users (Laricchia, 2023).

To replicate the experience of parents searching for relevant and appealing apps for themselves and their school aged children (6-10 years), specific searches were conducted in the *Health & Fitness*, *Kids*, and *Sports* categories of the App Store as well as using the search page to search across all categories. Search terms used to identify apps included: "family play," "family physical activity," "family activity," "kids physical activity," "family fitness," and "family exercise" on two separate iOS devices: an older iPad (5th Gen., iOS 16.7.10) and a newer iPhone (iPhone 13, iOS 16.7.10) in August of 2024. Each app was downloaded on both devices and trialed for a minimum of 30 minutes, which was determined to be sufficient time to assess features and trial out at least one of the app's activities.

Inclusion/exclusion criteria. The returned query of apps was narrowed to those available in English and/or Spanish; had a price less than or equal to $10 or have a free trial; have an Age Rating for adults (17+) and/or children older than five (4+ and not "Made for Ages 0-5"); and are not targeted towards a specific group such as users of a local parks department or school system. To focus on those apps that might be geared towards parents or family instead of a general adult population given Apple's Age Rating categories, apps also included those that appeared to be geared towards children/families (e.g. mention of family in the app description or child-friendly imagery such as animations) or those whose descriptions included mention of "fun," "play," or "games." Many of Apple's apps are rated for age groups 4+ due to "no objectionable material" (Apple, n.d.), therefore reducing the ability to assess which specific child age range apps are designed for (i.e., 6-10, 11-18, 18+ years, etc.).

The exclusion criteria were used to compare the apps that were readily available to most parents of elementary-aged students (6-10 years old) who may or may not have budgetary or language constraints. The resulting apps were reviewed by an independent rater (LVH) for inclusion of physical activity, play, and family involvement as defined previously.

Data analysis. App features were coded (1 for presence, 0 for absence) on the following: meeting active play criteria based on the definition outlined previously (unstructured/child-led, incorporates physical movement (e.g., instruction/direction), competitive, include objects (e.g., suggestions to use weights or balls) and fun) and family participation. Additional information was also collected including additional languages available, cost, and average user rating on the App Store. Apps were considered to include active play if they met the "physical movement" and at least one other active play criterion.

Active play criteria that were used for coding purposes are as follows:

Unstructured/child-led: an activity that is freely chosen by the child, without direction from an adult.

Physical movement: bodily movement that involves an increased energy expenditure from rest. Examples include running, jumping, and dancing.

Competitive: any construct involving a comparison of participants where one is considered "better" or a "winner."

Includes objects: an activity involving items to supplement the activity and the activity cannot be completed without. Examples include balls, ropes, or chairs.

Fun/enjoyable: the activity has qualities to motivate the participant to continue. Due to the likelihood that apps do not have a built-in "fun" measurement, for coding purposes, apps will be classified as fun if they meet the four criteria of a game: goals, rules,

feedback, and voluntary participation (McGonigal, 2011). Enjoyment will also be assessed with user ratings from the App Store.

Family involvement (or lack thereof) will be assessed using the following categories:

Solitary: activity is suggested to be completed by one child or adult without accompaniment.

With adult: activity is suggested to be performed with an adult in some capacity (observer, leader, or co-participant).

With others: activity can be completed with another person of any age.

A brief review was done by the first author to identify apps that were developed with specific theories, designs, or other commonalities in mind. This data was coded and grouped by the first author. Coding of the text-based data (first author review, description of app) was performed in NVivo (Lumivero, v15.0).

Descriptive statistics (frequency, percent) were collected to compare the number of apps included and their relevance to family play and PA. Descriptive statistics were also used to assess price, popularity (ratings), device compatibility, and language availability.

Results

Descriptive characteristics of the reviewed apps are presented in Table 1. Eighty-six apps went through an initial review to assess inclusion/exclusion criteria that was not obvious from the results page. During the initial review, the app was selected from the results page to view the landing page for the app itself. On this landing page characteristics such as target age, in-app purchases, reviews, and features of the app are described. After searches and initial reviews concluded, 57 apps were downloaded and further reviewed for active play components. Forty-four apps met all inclusion criteria and were trialed on an iPhone and/or iPad in August 2024, but

only 43 apps properly functioned to be reviewed (Appendix 2.1). Out of the 43 apps, 86% (*n*=37) met active play criteria, and 72.1% (*n*=31) included a family/non-solitary component.

The average size of the apps was 192.72 MB with the smallest being 2.37 MB and the largest being 980.8 MB. Most apps were compatible on an iPhone (100%), an iPad (83.7%), and an iPod Touch (93%). The most popular App Store category of included apps was "Health & Fitness" with *n*=24 (55.8%), but other categories included "Education" (*n*=9, 20.9%), "Family" (*n*=4, 9.3%), and "Lifestyle," "Sports," and "Entertainment" (*n*=2 in each, 4.7%).

Cost

While most apps were free to download (90.7%; Table 1), some paid apps also had a free version or free trial that allowed the user to test the app before being required to pay a monthly, yearly, or lifetime fee. Eight apps (18%) stated having a free trial period which ranged from 3 days to one week. Fourteen apps (32.6%) stated they had a free version of the app, allowing users to trial a basic version of the app which may have ads or a limited version of the premium version.

There were weekly fees of full or premium versions of the apps as low as $0.99/week and up to $7.99/week, monthly fees ranging from $2.49/month to $9.99/month and yearly subscriptions ranged from $22.99 to $69.99. Additional models of cost included one-time only "lifetime" fees ranging from $0.99 to $149.99 which would grant the user full access to the specific app, providing something as simple as an ad-free experience or as complex as a two-way video calling platform that allowed for interactive play between any two phones. It was also common to see additional in-app purchases such as buying more songs, games, or personalization features (i.e. personalizing an avatar).

Uses and Features of Apps

There were a variety of uses of the apps including simple activity trackers (*n*=2), libraries of activity ideas (*n*=6), "instructor" led workouts or activities (n=14), video games that did not include any physical movement (*n*=6), and fitness-focused (*n*=29).

While apps designed for specific populations were excluded, there were *n*=6 (14%) apps geared for more unique groups, but available to be accessed by the general public and therefore, were not excluded. These included apps created for research studies (*n*=3, 7%), for physical education teachers or educators (*n*=1), for homeschool families (*n*=1), and for Finnish and Swedish families (*n*=1). The activities in these apps were general enough to be used by anyone but provided specific insights into those specific communities.

Additionally, there were two apps (4.7%) that were developed by corporate sponsors (Hy-Vee Grocery, National Football League, and American Heart Association) and two that used popular children's characters (*Bluey* and *Masha and the Bear*).

Almost a quarter of the apps (*n*=10, 23.3%) used the technology of the device itself in the design of the game or feature. Six apps used the device's camera to analyze the user's movement. This was most used (*n*=4) in dance or movement games, where the camera was used to score a game, such as batting away lights or achieving certain dance moves. One app used the camera as the repetition counter for tracking the number of push-ups completed. Three apps used the device's location services to determine how far the user had moved to determine "steps" to further the game along (e.g. watering plants, tending a farm, accessing new games). Lastly, the physical orientation of the phone was also used as a feature of a video game, such as tilting the device in a certain way to advance or achieve a certain goal.

App Quality

The average rating of apps that had reported ratings (*n*=37) was 4.54 out of 5 (SD 0.36). The lowest user rating was 3.6 and the highest was 5.0. The average number of ratings among all apps was 11,017.4 where the lowest number of ratings was 0 (*n*=6) and the highest number of ratings was 344,000.

During trials, most apps functioned as intended (*n*=40, 93.0%). One app did not have a functioning video player that was meant to show the activity being performed (although it did have text descriptions of the suggested activity), one claimed to have a free trial, but the user was charged without including a free trial, and one was noted to be poorly made with various typographical errors present throughout the design. Additionally, there was one app that had to be excluded from the content analysis due to not functioning enough to be tested.

No app descriptions explicitly mentioned using a theory as a basis for the design, but three (7.0%) were designed specifically for physical activity research studies or by an academic. Interestingly, the three apps made for research studies were not particularly well designed; there were limitations in technology (*n*=1) and in being user-friendly (*n*=2).

Four more apps (9.3%) were developed in partnership with health-related institutions such as a physical therapy clinic (*n*=1), a grocery store (n=1), a Finnish institute that promotes physical education and wellness (*n*=1), and the American Heart Association together with the National Football League (*n*=1). These apps tended to have more functions, be more technologically advanced, and include a rewards system to encourage use. Interestingly, two of these apps also had more representation present in its characters or visuals that included various skin tones, hair styles, adaptive devices (i.e. wheelchairs) to choose from when building the player character than all other apps, which generally allowed the user to choose from two

genders and usually up to two skin colors, if at all. The least evolved design from this subgroup came from the app developed for the grocery store chain Hy-Vee. The games focused on health in general and did not include any physical movement.

Active Play Characteristics

The full sample of apps (*N*=43) was comparable across active play criteria compared to the subgroup (*n*=37) that met the physical movement and one other criterion to be classified as an app that included active play (Table 2). While Truelove et al.'s (2017) definition of active play does not specify that the activity should be solitary or with others, due to the research question, particular focus was on apps that had a family component. Of the 37 apps that included physical movement, three-quarters (*n*=28; 75.7%) could be done, or were promoted to be done, with another person (Table 2).

The large majority of apps in the active play subgroup were determined to have the potential to be unstructured or child-led (*n*=35; 94.6%) because the child could choose to use the app, choose the activity within the app, and choose whether or not to follow the guidelines that might be given. Additionally, about half of the apps (*n*=18, 48.6%) integrated a competitive component, commonly a reward system where the user could use the app or play the game at a certain level or for multiple days to earn badges or coins that would then translate to advancing in the game.

The use of objects within the apps (e.g. toys or equipment in some manner) was found in less than a third (*n*=11, 29.7%) of the sample. The most common "use" of objects were apps that provided libraries of activities that could be done for physical activity or play such as using a dumbbell for a specific exercise, a cone as a home base for tag, or a ball to play kickball with.

The “fun/enjoyable” criterion was common, but it can also be subjective. Using the four characteristics of games: goals, rules, feedback, and voluntary participation (McGonigal, 2011), led to 28 out of the 37 active play apps (75.7%) to meet the criteria. Voluntary participation is, like the “unstructured” criteria, with the assumption that the child is choosing to use the app as it is intended. Again, all apps were included due to being promoted for children or families to have fun or play in some capacity, so this count may be higher than if children aged 6-10 years were the ones to trial each app.

Lastly, more active play apps were designed to be solitary (*n*=32, 86.5%) than with others (*n*=28, 75.7%), but not by a large margin. It was more so that the activity could be done with others in addition to being able to be done alone than it was that the activity was intended to be done with others. There were instances where the games could be multiplayer, especially those that used the body’s movements to play the game, as well as the numerous apps that were libraries of activity ideas for a parent to do with their child. With only 28 apps including active play and being designed for multiple people, nearly two-thirds (65.1%) of the original 43 apps that were assessed are meant to be dyadic and active in a way that parents and children might be able to enjoy together.

Discussion

In this content analysis, apps developed for Apple’s App Store were trialed and assessed for their capacity to engage parents and their school-aged (6-10 years old) children in dyadic active play. Forty-three apps were determined to have met search criteria for apps designed for children and/or families to have fun and be active, but only 28 apps resulted in being designed to use for multiple people, resulting in 65% of the included apps being designed for dyadic active play.

While the apps were rated favorably by users, were free or affordable, and downloadable on the most common Apple devices, there were not any clear indications in the content of the apps themselves that indicated that they were specifically designed using any behavior change theory or specifically for dyadic active play. Parents generally do not seek these qualities when searching for an app to download (Brito & Dias, 2020), but they may improve the quality of the app and therefore its uptake. The categories that the apps in this review fall under (most commonly *Health & Fitness*, *Education*, and *Family*) are already not highly favored categories of apps to be downloaded and used (Al-Shamaileh & Sutcliffe, 2023), so other characteristics should be highlighted to promote consistent use.

While not many (n=11, 29.7%), some apps encouraged the use of some objects such as ball, weights, or craft supplies. This could potentially introduce an additional barrier to the activity after already overcoming a few (access to a smart mobile device, the potential cost of the app, free time, a safe play space, and a playmate). While barriers to play and active play have been studied in a variety of child populations (Brockman et al., 2011; Kottyan et al., 2014; Lee et al., 2016), knowing their child has access to a mobile phone is preferred by parents to have peace of mind in allowing them more independence (Brockman et al., 2011). Dyadic play may decrease the need for children to have constant access to a mobile device, but having one may improve dyadic play among peers, even with other potential barriers.

The enjoyment from play and physical movement makes active play a useful method of engagement for app developers as there are many apps for games, entertainment, and fitness. Depending on how one defines active play, may lead to finding more or less apps if replicating a similar review of app content. For the purposes of this content analysis, active play was defined as physical movement and a minimum of one other active play characteristic, some of which

may also be considered subjective and potentially different from person to person. Apps that promote physical activity in adults have been found to be of moderate quality (Paganini et al., 2021), use few behavior change techniques (Bondaronek et al., 2018; Middelweerd et al., 2014), and moderately effective in producing improvements in physical activity (Romeo et al., 2019). active play. Similarly, apps that promote physical activity in children are also of moderate quality but use more behavior change techniques (Schoeppe et al., 2017) and are mixed in effectiveness (Schoeppe et al., 2016). Future research should focus on the quality of active play apps and how the dyadic component affects behavior change, especially since behavior change constructs such as modeling and flow are particularly relevant for dyadic active play.

Strengths and Limitations

To our knowledge, this is the first content analysis to review apps that are designed for family active play and particularly for parents and school-aged children to be active and playful together. Since school-aged children are familiar with screens and are increasingly vulnerable to the harms of certain types of screen time like social media or TV-watching (Priftis & Panagiotakos, 2023; Sanders et al., 2019), it is beneficial to learn what parents currently have access to that would allow for them to participate in enjoyable and health-promoting ways with their children.

The search and analysis were performed by one individual as a part of a dissertation research project. This methodology did not include a second rater to corroborate reliability in apps meeting inclusion criteria, active play criteria, or coding of text descriptions. A more thorough search of specific behavior change theory constructs or using an established rating system (such as the Mobile App Rating Scale) may also indicate stronger and higher quality apps and should be considered in the future.

Due to the nature of the App Store under the operating system used at the time of this writing, an exact total number of results from each search is unavailable. Results do not provide the number of apps in each category or each search. As a user scrolls through the App Store, more apps load and leaving the App Store momentarily causes the search to reset.

Conclusion

Among recent parenting concerns are children's use of screens and the U.S. Surgeon General's advisory on the higher stress levels in parents compared to other adults and how it could affect well-being (HHS.gov, 2024; Priftis & Panagiotakos, 2023). This content analysis of apps designed for families to use mobile screens as a method to spend time together in an active and fun way is therefore current and pertinent for today's parents. At the time of this review, Apple's App Store had 28 apps that are designed for families to partake in fun physical movement together, or active play, whether through fitness programs, active video games, or by simply providing ideas for activities. Most apps are favorably reviewed and affordable (<$10/month), although it may take trial and error to find apps that truly meet the needs of families since approximately one in three apps that met inclusion criteria for the content analysis did not meet criteria for active play and was meant to be used in a solitary manner.

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Table 1. Characteristics of reviewed apps

	Number	Percent
Languages available		
English alone	25	58.1
English + others	18	41.9
Price		
Free	39	90.7
$0.99-$2.99	1	2.3
$3.00-$4.99	1	2.3
$5.00-$9.99	2	4.7
Compatible devices		
iPhone	43	100
iPad	36	83.7
iPod Touch	40	93.0
Mac	25	58.1
Apple Vision	25	58.1
Apple Watch	1	2.3
Average user rating		
4-5 stars	34	79.1
3-3.99 stars	3	7.0
1-2.99 stars	0	0
No ratings available	6	14.0
Age Rating		
4+ years	39	90.7
Made for Ages 6-8	8	18.6
Made for Ages 9-11	3	7.0
12+ years	1	2.3
17+ years	2	4.7

Table 2. Comparison of features across apps meeting active play and family activity criteria.

	All Apps Total *n*=43		**Active Play Apps Only Total *n*=37**	
	n	**Percent**	***n***	**Percent**
Active play criteria*	***37***	***86.0***	***37***	***100***
Unstructured/child-led	41	95.3	35	94.6
Physical movement	37	86.0	37	100
Competitive	21	48.8	18	48.6
Includes objects	11	25.6	11	29.7
Fun/enjoyable	34	79.1	28	75.7
Family participation	***31***	***72.1***	***28***	***75.7***
Solitary	37	86.0	32	86.5
With adult	28	65.1	27	62.8
With others	29	67.4	26	70.3

*Active play: physical movement and one other criteria

**Family participation: with adult or others (not solitary)

Names and Play Characteristics of Included Apps

App	Developer Name	Physical Movement	Unstructured/ Child-led	Competitive	Includes Objects	Fun/ Enjoyable	Family	Active Play
365 Games	Aleksander Ignjatovic	Yes	*	Yes	Yes	Yes	S, A, O	Yes
Active Arcade	Nex	Yes	*	Yes	No	Yes	S, A, O	Yes
Amanda's Action Club	Action Club Consultancy Ltd	Yes	*	No	No	Yes	S, A, O	Yes
Applaydu family games	Ferrero Trading Lux S.A.	No	*	No	No	Yes	S	
ARWell	Augment Therapy, Inc.	Yes	*	Yes	No	Yes	S	Yes
Better Together: Weight Loss	Social First Ltd.	Yes	No	Yes	No	Yes	O	Yes
Bluey: Let's Play!	Budge Studios	No	Yes	No	No	Yes	S, O	
Cadoo - Fitness Gaming	Cadoo, Inc	Yes	*	Yes	No	No	S	Yes
Exercise for Kids at home	El Mehdi DAOUDI	Yes	*	No	No	No	S, A, O	Yes
Exercise: At Home Workout App	Pavel Mylnikau	Yes	*	No	No	Maybe	S, A, O	Yes
Family Activities and Games	OdaMobil Teknoloji Limited Sirketi	Yes	*	No	Yes	Yes	S, A, O	Yes
Family Home Exercise	Ivan Romero	Yes	No	No	Yes	No	S	Yes
Fit Plants	Petr Pucek	Yes	*	Yes	No	Yes	S, A, O	Yes
Fitness for Kids: Kids Workout	AppsGO DOO	Yes	*	No	No	Maybe	S, A, O	Yes
FORTEe Get Strong	University Medical Center Mainz	Yes	*	Yes	No	Yes	S	Yes

FunDoRoo	Collective Mass	Yes	*	Yes	Yes	Yes	A, O	**Yes**
Geego: Move & Learn Skills!	Geego Kids	Yes	*	No	No	Yes	S, A, O	**Yes**
Heart Farming	Therese Kristoffer	Yes	*	Yes	No	Yes	S, A, O	**Yes**
Hy-Vee KidsFit	Hy-Vee	No	*	Yes	No	Yes	S	
Kids Exercise : Kids Workout	El Mehdi DAOUDI	Yes	*	Yes	No	Yes	S	**Yes**
Kids Experiments & Activities	Tappity, Inc.	Yes	*	No	Yes	Yes	S, A	**Yes**
Kids Workout & Fitness	Ayasis Yazilim ve Bilisim Teknologileri Anonim Sirketi	Yes	*	No	No	Yes	S	**Yes**
Kids Workout: Exercise at Home	AppsGO DOO	Yes	*	No	No	No	S, A, O	**Yes**
Kiorios Parenting	Navid Rezaeisarchoghaei	Yes	*	Yes	Yes	Yes	S, A, O	**Yes**
Little Sports Challenge	Roberta's Gym	Yes	*	No	No	No	S, A	**Yes**
Lose Weight Take Exercise	平类	No	*	No	No	Yes	S	
Masha and the Bear. Activities	Animaccord DTC LTD	No	*	Yes	No	Yes	S, O	
NFL PLAY 60	American Heart Association	Yes	*	Yes	No	Yes	S, A, O	**Yes**
Party Fowl	Nex	Yes	*	Yes	No	Yes	A, O	**Yes**
PlayLikeKids	Atahun Academy	Yes	*	Yes	Yes	Yes	S, A, O	**Yes**
QT30	Aloysius Bulter & Clark	Yes	*	No	Yes	Yes	A, O	**Yes**
RedZonkey - Fitness Buddy	Spontaneous	Yes	No	Yes	No	Yes	S	**Yes**

Rep Rise: Ultimate Workout AR	Mehdi Rashadatjou	Yes	*	No	No	No	S, A, O	**Yes**
Runbit	QuidBit AB	Yes	*	Yes	No	Yes	S, A, O	**Yes**
Savage Patch Kids	Savage Patch Kids	Yes	*	No	Yes	Yes	S, A, O	**Yes**
Sing Song Yoga for Kids	Sing Song Yoga LLC	Yes	*	No	No	Yes	S, A, O	**Yes**
SplashLearn: Kids Learning App	StudyPad, Inc.	Yes	*	Yes	No	Yes	S, A, O	**Yes**
Starri	Nex	Yes	*	Yes	No	Yes	S, A, O	**Yes**
Together: Family Video calling	Kinzoo Interactive Inc	No	*	Yes	No	Yes	A, O	
Vroom: Early Learning	Vroom	Yes	No	No	Yes	Yes	A, O	**Yes**
Workouts for Family	Wesam Khaled Alammouri	Yes	*	No	Yes	Maybe	S	**Yes**
Yoga and Exercise for Kid	Hoa Hoang	Yes	*	No	No	Yes	S	**Yes**
Yoga at Home for all Family	Tu Tran Duy	Yes	*	No	No	Yes	S, A, O	**Yes**

*indicates "possibly" – While there is no instruction from an adult, the child may choose to do the activity on their own, and may or may not follow the guidance provided; S: Solitary activity; A: Activity that is completed with an adult; O: Activity that is completed with another person, but not necessarily an adult.

ARTICLE 3: EXPLORING MOTHERS' SUPPORT OF ENGAGEMENT IN PLAY AND PHYSICAL ACTIVITY WITH DAUGHTERS

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Abstract

Background: Across the lifespan, women and girls tend to be less physically active than males, putting them at greater risk for chronic disease. Choosing physical activity that is enjoyable is often recommended to maintain habits, making play a potential moderator for physical activity engagement. Play is often associated with children but is an activity that parents and children can participate in together. Mothers' perceptions of play, physical activity, and quality time with their school-age daughters (6-10 years old) were recruited to determine how play can potentially influence physical activity in females. ***Methods:*** Purposeful sampling was used to recruit typical-case mothers with school aged daughters with whom semi-structured qualitative interviews were conducted. ***Results:*** Eight mothers with daughters aged 6-10 years were interviewed in summer of 2023. The women were from three U.S. states, majority White-identifying (n=7), and were aged 38.5 ± 6.4 years with daughters 7.5 ± 1.3 years. Mothers discussed the importance of play and physical activity both for themselves and their daughters, but noting it was difficult due to work and motherhood responsibilities. Mothers placed higher importance on quality one-on-one time with their daughters and activities to aid in mental and physical stress for themselves, often citing qualities of play for each, but not qualities of physical activity. ***Conclusion:*** While playful physical activity with their daughters is difficult to achieve, mothers do place importance on play, physical activity, and quality time with their daughters. This study highlights the difficulties that mothers have in dyadic active play with their daughters but can inform future interventions and research in prioritizing mothers' time for themselves and quality time with their daughters in both active and non-active ways.

Introduction

Most adults and children in the United States are not meeting recommendations for physical activity (PA) levels with potentially serious future health consequences (National Center for Health Statistics, 2018; Physical Activity Alliance, 2024). Sedentary lifestyle increases the risk of cardiovascular disease, diabetes, osteoporosis, depression (Park et al., 2020), and severe COVID-19 outcomes (Sallis et al., 2021).Women tend to be less active than men with 27% of men meeting aerobic and muscle-strengthening PA recommendations compared to 20% of women (National Center for Health Statistics, 2018). The trend begins in youth as girls tend to be less active than boys. Analysis of the International Children's Accelerometry Database found that the average boy aged 5-18 years met PA recommendations of 60 minutes of moderate-vigorous PA daily, but the average girl only had 40 minutes of MVPA (Kretschmer et al., 2023).

PA levels also decrease as people age with males meeting recommendations more frequently than females across the lifespan. Among adults aged 25-64 years, 27% of males met recommendations compared to 20% of females, in those 65-74 years it decreases to 18% versus 13%, and in adults 75 years and older it further declines to 13% versus 8%, respectively (National Center for Health Statistics, 2018). Due to all age groups experiencing physical inactivity, PA interventions focusing on families or parent/child dyads can improve PA levels and potentially improve the overall health of families. Family behaviors can be a major source of influence for children in modeling health behaviors such as PA, making it a useful method for interventions, particularly in children (5-17 years old) (Kahn et al., 2002; Rhodes et al., 2017b). While reviews of child PA interventions cite mixed effectiveness (van Sluijs et al., 2007), it

appears that those that are home-and family-based may have improved effectiveness compared to those that are community-based (H. E. Brown et al., 2016; van Sluijs et al., 2011).

PA recommendations for both adults and children include participating in enjoyable and motivating activities, but play, an activity that is typically classified as “fun,” is only encouraged for children to be active (U.S. Department of Health and Human Services, 2018). Since play has the capacity to be active and it can be done together among parents and children, it may provide an opportunity to increase PA in both parties, particularly in groups that are less likely to meet PA recommendations such as girls and women. Adults should also participate in play because it allows for creativity and self-expression, promotes fun and reduces stress, aids in learning to take things in stride, and models lifelong play for children (Baptiste, 1995). Adult play and playfulness are largely lacking in the research literature (Proyer, 2017) and even though females are less active than males, there are few known studies that focus on mother-daughter dyadic play and PA behaviors. Two systematic reviews have been performed on mother-daughter PA interventions, but neither assessed how play might influence the intervention or PA itself in either the mother or daughter (Barnes et al., 2018; Brennan et al., 2021). Barnes et al. (2018) reported that the mother-daughter PA interventions that do exist, are not of high quality or effective in improving PA levels.

Mothers spend more time than fathers with their children, but this is not the case when looking at play behaviors (U.S. Bureau of Labor Statistics, 2023a). Women spend more time in household duties such as cleaning, food preparation, and household management (U.S. Bureau of Labor Statistics, 2023b) which adds to their perceived barriers to PA that include a lack of time, childcare, and social support (Abbasi, 2014; Moreno & Johnston, 2014). Qualitative and cross-sectional research with parents has explored parent perceptions on play and PA (Bringolf-Isler et

al., 2010; Faulkner et al., 2015; Tappe et al., 2013), but has yet to explore the current behaviors and barriers concerning play in a population that has decreased PA, but also suffers from increased familial pressures. It is possible that by playing in active ways with their daughters, it would eliminate the barrier of needing childcare or social support and encourage enjoyable physical activity, therefore improving PA levels in women and girls.

This qualitative study investigates how mothers spend time with their daughters in play and PA-related activities. By exploring the mother-daughter relationship, it is possible to learn about how play might affect mothers' PA and learn if play can be used to influence mother-daughter dyads' PA. The knowledge of how mothers might play with their school-aged daughters (6-10-year-olds) has the potential to inform family-based PA interventions that may increase the percentage of the population who meet PA recommendations. Women and girls are prioritized as they are a group that tends to be less active and therefore more information can be gathered to inform the literature on their attitudes and experiences with play, PA, and dyadic activity.

Methods

Study Design

Participants were recruited through approved flyers shared with personal and professional contacts through social media (Facebook and Instagram), a southeastern U.S. graduate school newsletter, and flyers posted at a women's health clinic and a childcare center (U.S. Midwest). Recruitment e-mails and posts included some of the inclusion/exclusion criteria, purpose of the study, expected time commitment, contact information, and a link or QR code that directed the interested participant to complete an online questionnaire to determine eligibility (Qualitrics). Participants were also encouraged to share the original study recruitment announcement within

their social networks via word-of-mouth, social media, or e-mail. Participants were incentivized with a $10 Amazon e-gift card for participating. All procedures were approved by University of North Carolina Charlotte Institutional Research Board (IRB-22-0332).

Sampling

In order to gain the most understanding about play and PA in families, purposeful sampling was used to recruit parents for qualitative interviews. Typical cases of female-identifying parents with female-identifying children were recruited to find a commonality of whether mothers are active with their daughters or if they tend to not prioritize family play/PA and to study it in depth (Patton, 1990).

Mothers qualified to participate in the study if they were at least 18 years old, identified as female, and had at least one female-identifying child between the ages of 6-10 years. Participants needed to speak English or Spanish, reside in the U.S., and have no contraindication to PA (e.g. high-risk pregnancy, disability with mobility impairment, etc.). Contraindication to PA for the daughter was not an exclusion criterion, as they would also play and be active as they are able, but it was ultimately not a factor in the final sample.

Procedures

A potential participant expressed interest in the interview by completing the secure online survey in either English or Spanish (Appendix 3.1). The survey ensured the potential participant met inclusion and exclusion criteria as well as provided an opportunity to capture some demographics on themselves, contact information, their capacity for participating in an online video interview, and provide an online informed consent document for their review. Once eligibility was confirmed, the interviewer reached out via the preferred method of communication as outlined in the survey response to schedule the online interview with the

participant. A Zoom invitation with the secure link was sent to the email provided after scheduling.

Shortly before the scheduled interview, the informed consent form was sent via DocuSign with instructions to wait until the interview to open and sign the form. The qualitative interview session (using Zoom) began with introductions and the informed consent process. After both parties signed the consent form, a signed copy was sent to the participant's email address, permission to audio-record the interview was requested, and then the interview began.

Guided by social-cognitive theory and flow theory, semi-structured interview questions were developed to best answer the research question of perceptions of and barriers to play and PA (Appendix 3.2). Social Cognitive Theory allows for the case that the environment (mother-daughter relationship, modeling, safe play spaces) might influence a behavior (dyadic play and/or PA) (Webber-Ritchey et al., 2018) and flow theory explains the circumstances when one might choose a play or PA behavior (depending on perceived capabilities and opportunities) (Nakamura & Csikszentmihalyi, 2014). Semi-structured interviews allow for reflexive discussion between the interviewer and participant and therefore more room for probes for exploring answers to research questions (Dudley, 2005, p. 162-163). The goals of the interview were to understand how parents view physical activity and play separately, and what they perceive to be barriers to each for themselves and their daughters. To encourage participants to discuss their play and activity culture, descriptive questions were included in the interview protocol such as grand- and mini-tour questions (e.g. "Tell me about a typical day for you"), example questions (e.g., "What are some examples of some games you play with your daughter"), and experience questions (e.g., "Tell me about an experience that you have had playing an active game with your daughter") (Spradley, 1979). The interview protocol also included follow-up prompts with

each question to promote discussions of participants' experiences and ideas that may lead to emerging concepts. Mothers were also asked to describe themselves and their families to collect demographics and additional information that may influence their answers (size of family, employment, neighborhood characteristics, etc.).

Data collection

Participants completed face-to-face qualitative interviews via Zoom online video platform in July 2023. Video interviews allow for similar ethical considerations as in-person interviews, such as allowing the participant the option to leave at any moment and allows for similar data integrity and quality as in-person interviews (Janghorban et al., 2014; Shapka et al., 2016). Online platforms were not considered a barrier due to most families being familiar with video conferencing due to the COVID-19 pandemic causing many jobs and schools to use these methods for remote work or e-learning. Online video interviews can also eliminate other barriers to participation for mothers in qualitative studies such as time constraints due to families or jobs, concerns with transportation, and physical or geographical limitations (Vinoski Thomas et al., 2019).

Data analysis

Participants were informed of the option to provide a pseudonym for themselves and their daughters, but none chose to do so. Interviews were anonymized and transcribed verbatim by the interviewer (LVH) as soon as feasible following the session. Transcripts, field notes, and journals were uploaded to qualitative research software (NVivo v 14.0, Lumivero) to be analyzed. A codebook was created and shared with a second coder (JWF) after the first three interviews. Discrepancies in agreements with codes of an interview were discussed until a final

coding guide was established with the understanding that the codebook may continue to evolve with each following interview.

Rigor

To increase the probability that credible findings were produced, enough participants were interviewed via purposeful sampling to understand what is not known by the interviewer by not being a parent of a 6-10 year old, and efforts were employed to recruit "typical" mothers by using a variety of sources for the interviews: female-identifying parents ("mothers") of female-identifying children ("daughters"), mothers of daughters from the entire range of 6-10 years, and mothers of various U.S. racial, ethnic, and geographical groups.

Various examples of the responses given by typical cases are provided to provide as thick and rich of a description as possible to promote *transferability* of the data to other typical cases of mothers with daughters in this age group (Lincoln & Guba, 1985). Additionally, the interviewer established rapport with participants by providing the opportunity to be interviewed in English or Spanish, sharing similarities with the participants when relevant (e.g., graduate student, mother of a daughter), asking grand-tour, experience, and example questions (Spradley, 1979).

Results

Forty-two responses were received via the eligibility questionnaire. Seven were deemed ineligible due to incomplete responses, another seven were deemed ineligible based on their responses (i.e. answered "yes" to having a contraindication to PA or "no" to having a daughter), and 22 were eliminated after Qualtrics location data confirmed ineligibility based on surveys being completed outside of the United States. Ten women were contacted and eight completed interviews. The women were from three states (North Carolina, Minnesota, and Ohio) and all

resided in (or in the suburbs of) a major metropolitan city. The women identified as White (n=6), Black (n=1), or both White and Black (n=1), and seven of the interviews were conducted in English; the remaining interview was conducted in Spanish. Additionally, seven of the eight women also stated that they were married or living with a partner except for one, who stated she was separated. Their ages ranged from 31 to 48 (average age: 38.5, SD 6.4 years) and they discussed their daughters ranging from ages six to nine (average age: 7.5, SD: 1.3 years). All eight women stated they lived in single-family homes with yards and a safe, walkable neighborhood. While given the opportunity, none of the women chose to give themselves or their daughters pseudonyms (Table 1).

Time Spent Together

When asked about the time they spend with their daughters, mothers did report spending both active time with their daughters as well as sedentary time. Commonly, sedentary examples include playing games, screen time, and arts*: "We'll… Sit and watch a show together. Sit on Snapchat and send Aunty videos* (Helen)"; *"We try to do something inside… so we'll do Legos or play a game, or [Daughter] loves to do art. And so we'll do drawing or crafts* (Ava)*"; "[Youngest daughter] will usually choose like a movie. And we'll sit on the couch and typically I have my, like, lap desk on my lap with my computer on it. But you know, it's a way to try and give some time while also being able to take some time* (Barbara)"; and "*We just got this new chess set that we really love. And so it was great because she's pretty good at chess and I'm not. So she was able to explain it to me. She was showing me some videos, so that was really a fun time. We were kind of learning together. But still doing something fun* (Felicity)."

With the interviews being conducted in the summer months when school is not in session, water activities, being outdoors, and going to playgrounds were common active

activities where mothers and daughters spent time together: "*We just do all kinds of things. I like for us to stay active, so we're just at the park or at the pool or at family's house, I mean it just varies day-to-day. Yeah, normally if I ride my bike, she rides her scooter* (Elizabeth)"; "*We like to go to the trampoline park. We like that. So that's. That's one of our places that we like to go, chase each other around* (Felicity)"; "R*ight now the pool. Always the pool* (Cristina)"; and "*Yeah, we're actually trying to this summer. That's like a goal of mine is for me and her to be more active outside. Do… less technology and more activities* (Elizabeth)."

Mothers discussed the importance of spending quality time together with their daughters, especially in the instances of co-parenting or having more than one child. For example, one mother stated, "*It's hard when you have so many kids to do 1 on 1 time* (Barbara)." Mothers are purposeful with ensuring each child, including their daughters, have time alone with them: *"Once a week - it's typically like on a Thursday - I'll call them in one by one and they have dinner with me. Just one-on-one. Yeah. So they'll have dinner with me, and it's always like it's Turkey sandwich Thursday. So we have sandwiches and chips, so it's not like a long time that you'll be without your siblings. So that way you come eat with mom, if there's anything you want to just tell me about yourself* (Felicity)*."*

Often, time spent together is thought of as quality or one-on-one even if they are running errands together, unwinding at the end of the day, or doing household chores like cooking or laundry together. Older daughters enjoy going to malls or getting manicures with their mothers while younger children enjoy going to the playground or playing games with their mothers.

Perceptions of Play and PA

Mothers believe play is important for their daughters to enjoy themselves, use their imagination, learn about things like social relationships and communication, and to take breaks

from life. They also believe that play for themselves might be more structured or scheduled, and it is also important for mothers to "*disconnect*" from life's responsibilities.

For their daughters, mothers do not always perceive play to be a freely chosen activity, and that perhaps its greatest benefit was the learning gained from play. For example: "*Especially like with cheer, like structured play helps her get out her energy, but also learn like the parameters in which to like focus herself. So I think like play is important because like her socializing is important and her getting out that energy is important. But I also really like that structured play where she's also learning like how to control impulsivity and different things like that. You know, especially with some of the challenges she has [with learning disabilities] to be able to really like kind of refocus her, I think is helpful* (Barbara)*."*

Additionally, one mother perceived that interaction with an object, or another person was important in play: "*I think to me [play] would mean just interacting in stuff with- in some activity so even if it was like a puzzle… Or if we were role-playing, you know, just really that one-on-one undivided interaction on some activity or like sitting down and drawing? I would consider that play as well. Same thing with playing tag, you know… I think especially if you're doing it with somebody, so just that engagement and communication and sharing of ideas.* (Diana)*"*

Mothers also appreciated the simplicity that play could be – that their daughters appreciated pretend play with objects that aren't necessarily toys and that this is still seen in the older daughters in the cohort. Examples include: "*Barbies is a big thing. She's kind of still, in the young enough phase, I feel like we're kind of going to lose her after a year here on that, but she… Like imaginary play is really big for her, her and [brother] will often just make up, like play baby, or play restaurant or play-whatever camp or school and. Just like become these other people* (Helen);" "*She loves anything pretend to play like she has a little like grocery store that*

she uses, right now it's set up as a pet store, but she's just very pretend play. She likes that more than anything, Barbies. Anything she can use her imagination on like we don't really play much board games or things like that, but anything pretend play she's very, very into. Baby dolls pretending to be a mom (Elizabeth);" and "*Ese tipo, a veces cosas sencillas, ellos le gustan más… Ayer la idea era hacer un spa… Ella tiene muñecas, las casitas de para las Barbies. Y también los niños son muy imaginarios y ella coge varias sábanas en la sala y hace una casa. [Yes, that, sometimes they enjoy the simple things more… Yesterday they had the idea to play spa… She has dolls, the houses for Barbies. And the children are very imaginative and she'll get blankets in the living room and make a fort,]"* (Georgia). Mothers even emphasized the importance of the simplicity of play: "*I think I, think play is just one of those things that you just let the kids go. See what happens… I think it's just letting your imagination just go* (Ava)."

A commonality that was not explicitly asked but came up with several mothers was the difference between how they play with their daughters compared to their partners or even how their parents played with them as young girls. One mother stated: *"I'm noticing that I think I'm just, every free second, I have we play with her… But I'm just noticing how different that is from me growing up. I don't really, I mean my dad always played with us, but it's still like. I don't think they played with us that much. I think I play a lot more with my children than my parents [did with me]"* (Cristina).

Some mothers stated that fathers tend to participate in rough-and-tumble play with the children that mothers either do not prefer to engage in or can't because of other responsibilities: *"He'll take the kids outside and go play with them while I make dinner… Dad is usually actually the better player because he is way more animated and there usually ends up being somehow karate kicks and fights and different things. But oh my gosh, you know, like guys I can't play like*

this" (Ava); or "*They do more wrestling and kind of rough housing. He likes to help her practice with her karate kicks and things"* (Felicity). One mother even mentioned that she felt "horrible" when talking about how her daughter enjoyed pillow fights or wrestling, highlighting a difference how mothers may perceive play to be gentle, while fathers enjoy roughhousing: "*It sounds horrible, but we do like pillow fights… Well, we play wrestling games. I hate to say, I feel horrible because I'm like whoa. It's wild* (Cristina)*."*

Mothers also perceive play to have goals and be competitive while ultimately providing a space for their children, and themselves, to be challenged and allow for a break in responsibilities or life's stressors. A mother that takes her daughter camping with Girl Scouts perceived the structured activities as play: "*I would more consider like the Girl Scout camping play because we are doing focused activities. Though it's like, OK, you're going to, you're going to make a birdhouse, you go do that with your mom… However, I would say when I just take her like on a nature walk or like hey, we're going to go walk the dogs. Maybe I wouldn't necessarily consider that play because it's less focused*. (Diana)" When asked what play was for her, a mother stated "*Cuando pienso jugar el juegos pienso más en juegos algo que te rete. En un juegos de mesa. ¿O los video Games?... que envuelva a competencia [When I think of playing games I think of games that challenge you. Table games. Or video games?... Something that involves competition]* (Georgia)."

While mothers had varying views on play, most brought up the difficulties that motherhood or adult responsibilities presented in playing with their daughters (Table 2). All mothers interviewed worked outside of the home and most had a partner and other children to share time with, which could influence some of the burdens mothers feel in participating in an enjoyable activity for themselves or with their daughters.

PA and Play Behaviors

There were examples of mothers discussing how important physical activity is for their physical or mental health: "*I was recently in January diagnosed with a rare form of cancer. So because of that, our family really takes time to really just try to be active and be present and be together.* (Felicity); "*Ya cuando uno entra a los 40 años la actividad física, el ejercicio, es parte de tu día. Que no entonces te sube el colesterol y todas esas cosas. Y yo estoy bastante consciente con la salud. [When you get to be 40 physical activity, exercise, it's part of your day. So your cholesterol doesn't go up and all that. And so I am pretty conscious of my health.]* (Georgia);" "*[Being active] helps me clear my mind. I feel better holistically when I'm active or moving* (Helen)."

Additionally, mothers discussed the importance of being active with, or for, their daughters for both parties' health: *"Para mí es importante que ellas también se envuelvan en hacer algún tipo de actividad física, porque lo que tú aprendes de niño es lo que tú vas a hacer en tu adulthood. Si tú no creas esas rutinas de pequeño es difícil que después de grande las haga. [It's important for me that the girls are also involved in some kind of physical activity, because what you learn as a child is what you do in adulthood. If you don't create those routines in your youth it's difficult to do it later when grown]* (Georgia); "*I wanna do this stuff with her. I want to play soccer with her, you know? … She likes racing and running and then she says, 'OK, I'm going to ride my bike. You race me to the stop sign.' I can't. You know, I wish I could, but… we try* (Diana)."

Being healthy for themselves and their daughters also leads to ensuring that the PA they engage in is something they enjoy: "*I am not somebody who goes who enjoys going to the gym and lifting weights. But I enjoy being outside, taking hikes, going rafting, going tubing, you*

know, like I enjoy those kinds of things, which you have to have some kind of physical strength for. So I feel like it's somewhere right in the middle there? Where although it's not something that like, I'm like, oh, that's what I value most, it's definitely something I understand from a perspective of if I'm going to do the things that I enjoy to do I can't be ridiculously large or unhealthy (Barbara);" "*Before the girls we used to go to the gym for an hour before work… And like, just schedule-wise it just doesn't work anymore. So instead of feeling bad about it, I'm just gonna, at least gonna try to, you know, go on a walk or it's so much easier…. You just feel better when you get outside or get, you know, that activity. So I think it's really important for the girls and they always want to be outside and doing things. So I try to make it a priority as much as I can in my life. But also knowing that life is hard, and you only can get so much done in the day. And so that's why I've been trying to prioritize, even just having like a 15–20-minute walk by myself when the girls go down to sleep, like [Husband] will stay home with them, just because even just having that alone time and then being able to kind of decompress, I know, is important* (Ava)."

All mothers expressed that physical activity is important for physical and mental health, allowing for a space for them to take care of themselves. There were also explicit expressions about how important being active is for keeping up with their children. Mothers try to stay active by doing structured exercise, doing something active with their family, or doing something that they enjoy, even if that is alone.

Moderators to Play/PA

Mothers discussed various moderators to being active or playful with their daughters including their jobs, their other children, parenting responsibilities, as well as their homes and neighborhoods.

All mothers interviewed had at least a part time job or other commitments (e.g. enrolled in graduate school) that could cause a barrier to playing or being active with their daughters. Four mothers expressed working in or having experience in education which allowed them to have summers off. Three participants briefly brought up their ability to occasionally work from home, but that was not a topic that was brought up in every interview and therefore, could have been higher. Needing to get work done while their daughters were also home was therefore a barrier to playing with daughters: "*I have to say no a lot. Because I'm in the middle of work. And she's in summer school, but not for a full day and not on Fridays. So then she's like, 'Mom, I wanna do this' and I'm like, 'I'm still working…' But you know, I have to say no a lot. So I try and I try and make it, especially if they bring me Monopoly I'm going to have to be like, that is probably not going to happen right now [because it is a longer game]. But I'm like, OK, we can get through a game or two of Sorry* (Barbara)."

There is also the barrier of household chores that mothers feel they need to balance with work and spending time with their daughters. While the participants expressed that it was difficult to balance all the parts of motherhood, it was also important to them to show their daughters that they would incorporate them in some way by setting aside some time, "*So there are times where I just have to like literally set a timer on my phone. Give her some time and focus. And then when that focus is over. She's gotta let me, you know, go do other things* (Elizabeth);" or by attempting to make chores playful for their daughters: "*I notice now when she's older, you know, it helps us to incorporate her in. And like, when I have to do something. You know, even with, it's like putting away the laundry well she has to get all the socks together or something. That's her mission. You have to make it a mission or something, right? Find all the matching socks. Something you got to just do it somehow* (Cristina)."

As mentioned previously, others in the home also made spending time with their daughters difficult for mothers. Mothers balance the fact that their daughters do have a playmate and it doesn't always have to be them, even if it means they don't spend as much time playing together: "*I mean, now that [Daughter 2, age 4] and [Daughter] love playing together, they… just play so great together. I mean, like I would say they get along 85-90% of the time. It's like the best thing in the world. And then I also feel that I'm not as present in that because they're playing so well together. So really working on that balance. Of yes, there are things that have to get done, but also play is important for them, for me. For us to build that relationship* (Ava)." Additionally, mothers find that their time spent together is shortened due to structured activities and daughter's siblings: "*I feel like she is very active, but partially because of you know [me being in school] and partially because of her being the last child we don't have as many opportunities-- I try and make opportunities for her to be active. I'm very good at dropping off and picking up at cheer practice. But the opportunities for us to be active together. Aren't as often for sure* (Barbara)."

When asked about their daughter's play and PA spaces, mothers described their homes and neighborhoods as being very conducive to indoor and outdoor play. All daughters had dedicated play spaces in their homes, yards, and neighborhoods that encouraged play and PA. This promoted family PA in the form of walks or bike rides, but also highlighted that these mothers already likely prioritized safe outdoor play by choosing safe neighborhoods.

Playgrounds were walkable for most families and neighborhoods had other amenities such as pools and sidewalks. While playground attendance may have been increased due to the summer months, the proximity of play spaces, play mates, and the safety of neighborhoods allows for more opportunities for play (Table 3). Additionally, the outdoors was a common play

space for both daughters and mothers. Having a back yard that was always accessible was important for mothers, but they often viewed outdoor walks or other outdoor play spaces, even if not in the neighborhood, as an outlet for play.

Play as PA Moderator

Play is an activity that is generally done for enjoyment and not for a defined purpose. As discussed previously, when mothers define play, they also often mentioned that it is a mental break, often a creative task, but one that can be done with structure, alone or with others, and might be active or sedentary. For mothers, they often expressed that their favorite things to do were to share experiences with friends and family with no purpose other than enjoyment, but also to be alone and to unwind: *"My downtime I guess is my fun time. I mean I get out with friends. We go to breweries. Yeah, I mean, I guess I like to do that for fun… wineries* (Elizabeth)."

Interestingly, when discussing what they did for PA, mothers regularly mentioned that they sought physical activities that were enjoyable for them. The activities might be structured or with others, but by understanding how important PA was for their health, they ensured that they chose activities that they would stick with. *"I'd say my [gym] is me trying to live a little bit better. You know [the gym] is more of like that I have to do something. Whereas hiking is. Like, ooh, hiking* (Barbara)." This indicates that playfulness could be considered a moderator of PA for mothers.

Mothers often perceive some of their daughter's play as active, having goals, and having structure. When they take part in their daughter's favorite activities, mothers focus on their daughter's enjoyment over their own and prioritize the time spent together instead of their own needs: "*She loves to go shopping. That is not necessarily my favorite activity to do, but like she loves the [mall]. And so we… She'll ask to go there all the time.* (Helen);" "*Like, let me tell you*

like. I'm not a roller coaster fan, but the kids love to go to [amusement park] on the weekends, so I take them. If I can dip my feet in their water park and cool myself off, I'm good. I am really good at holding bags while they ride roller coasters. I know my value, I know my worth (Barbara)."

Since play is not always active for the daughter and not always as enjoyable for the mother, play may not be a moderator of PA for the mothers in this cohort. At the same time, mothers acknowledge the importance of unwinding and doing something they enjoy for themselves, which they might not explicitly define as play, but is a playful characteristic that is often associated with their approach to PA. PA may therefore be a moderator to play for mothers.

Discussion

From this qualitative interview study, it was learned that mothers of daughters ages 6-10 years old value spending quality and enjoyable time with their daughters but struggle due to work and motherhood responsibilities. The quality time spent together may be playful, and in the summer months when their schedules allow for it, is often outdoors and active. PA was often seen as an activity that brings enjoyment in some way. Exercise alone or PA with friends and family was discussed as a method of unwinding, to take breaks from stressors and responsibilities, but also a way for their daughters to experience physical or social challenges and a gateway for communication between mothers and daughters. "Play" for mothers was also often both something they could enjoy alone in order to take a break from motherhood, but also a structured activity that allowed them to enjoy spending one-on-one time with their daughter.

This study is the first known study to explore qualitatively how mothers and daughters spend time together in general, in play, and in active ways. The relationship between mother and daughter's health behaviors has been shown to be strong as they both can influence each other

(Greenberg et al., n.d.; Maltby et al., 2018; Poulain et al., 2019). As it relates to PA, it is seen that active mothers typically have active daughters (Yoon et al., 2018). While mothers in the current study were asked about their own PA behaviors, they generally expressed knowing it was important for them to incorporate, but they did not all prioritize it as much as they did for their daughters. Mothers in this cohort supported play or PA in their time spent with their daughters by ensuring that they carved out time for their daughters, choosing safe spaces to live and play, and taking their daughters to activities that they enjoy.

When they think of play, mothers often think of imagination, objects, and competition while also realizing its importance in learning for children. They also associated play with outdoor spaces which increased the capacity for the play to be active. This is in opposition to a qualitative study that found that both parents and children viewed physical activity and play as different activities even though they agreed that enjoyment was important in participating in physical activity (Curtis et al., 2012). But parents also have been found to associate outdoor areas such as the playground as a key space for active play (Veitch et al., 2006). A recent study interviewed fathers and mothers on their perceptions of play, and mothers also mentioned that play was important for child development like in the present cohort and it was noted that fathers also engaged in more rough-and-tumble play, something that was noted by several mothers in the present study as well (Moon-Seo et al., 2024). Brown (2009) outlines the various categories of play such as imaginative play, object play, structured play, and physical play, which the mothers in the current study all allude to recognizing in their children and themselves.

A similar study was recently published that asked mothers about their PA support behaviors towards their daughters ages 10-12 years (Brennan et al., 2024). The authors also found that mothers support their daughters in active ways, especially if they prioritized PA.

Additionally, mothers discussed the PA support of others in the family and the community environment similarly as the present study. While play was not explored in that cohort, it could be said that mothers in other parts of the world and with slightly older daughters, also view PA as important for their daughters, but also associate it with structure (i.e., rules or sport) and being outdoors (Brennan et al., 2024).

Moderators to play between mothers and daughters included others in the home, work or school, and availability of safe play spaces. Parent's perception of safety and how it influences their child's play and PA is well-documented (Bringolf-Isler et al., 2018; Galaviz et al., 2016; McDonald et al., 2015; Rothman et al., 2015) and parenthood influences PA (Palomäki et al., 2023). Additionally, the age of the youngest child influences parent PA (Palomäki, et al., 2023). However, across all women, barriers to PA do include lack of time due to work and family, but also self-consciousness about their body and physical abilities, anticipated lack of enjoyment, and urinary incontinence (Moreno & Johnston, 2014). If mothers are active without their children, the lack of childcare and feeling selfish for taking time away from their family adds an additional barrier for this group (Moreno & Johnston, 2014). Furthermore, urinary incontinence is related to pregnancy, childbirth, and age, (Fritel et al., 2012) indicating that mothers specifically may experience this barrier more than men or women without children. There are no other known studies that have examined mothers' perceived barriers to play with their school-aged daughters.

Strengths & Limitations

This study adds to the literature by exploring mothers' current behaviors and perceptions to play and physical activity with their school-aged daughters. The differences between male and female parenting, play, and PA behaviors have been explored separately, but focusing on

mothers and daughters highlights a group that is at greater risk of falling short of meeting PA guidelines and by focusing on an age group of girls that begins to see the disparity in PA compared to boys.

Methodologically, purposeful sampling of a diverse group of mothers with daughters aged 6-10 years old living in the U.S. allowed for selecting information-rich cases while also yielding a sample size that is manageable (Patton, 1990). Many common themes were discovered throughout the eight interviews indicating that *redundancy* was achieved (Patton, 1990).

While recruitment was conducted across various states and mediums, the most fruitful recruitment method was through a graduate school newsletter, leading to having a sample where most participants were educated and living in the southeastern U.S. This also could have led to the commonality that all participants worked outside of the home, lived in single-family homes, and in what they perceived to be safe neighborhoods. Future research should expand the sample to include other potential barriers of PA and play such as single parents, those living in multifamily housing, and/or specifically in rural or urban areas. While this could have been a limitation in certain ways, it also allowed for *trustworthiness*, as the interviewer was also a graduate student with a daughter.

The interviews in this study were limited to the summer months and were largely in a population that had flexibility from their jobs or school to be present, which is not always the case for working mothers. But by conducting all interviews in the summer, it was possible to explore time spent together between mothers and daughters without the constraints that the school year might provide. Additionally, summer months provide additional opportunities (and barriers) to outdoor activities such as vacations, visiting pools, amusement parks, or simply more family walks in the neighborhood.

Implications for Future Research

Mother-daughter dyads require additional attention in order to improve PA levels overall and potentially decrease the disparity that is seen in PA behaviors between males and females across the lifespan as well as between parents and non-parents. By exploring play and its relationship to PA, there may be an avenue to promote PA to be more enjoyable for this group. Mothers were found to gravitate towards PA that is enjoyable, but also wanting to spend quality time with their daughters in an activity they enjoy and gain something from, even if it meant that their daughter's desires and needs overrode their own. PA interventions should develop playful and enjoyable ways for mothers to feel as if they are spending quality time with their daughters and that the girls are benefiting from the act of being physically active.

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Table 1. Summary characteristics and pseudonyms of participants.

	Mother Name*	**Mother Age (years)**	**Daughter Age (years)**
	Ava	34	6
	Barbara	37	8
	Cristina	36	6
	Diana	31	8
	Elizabeth	33	6
	Felicity	48	9
	Georgia	47	8
	Helen	42	9
Average	-	38.5 (SD 6.4)	7.5 (SD 1.3)

*Pseudonym provided by first author

Table 2. Examples of difficulties that mothers have in playing with daughters.

"We think about it as play for kids, but for us it really is about taking time for ourselves and caring for ourselves and doing things that we enjoy and, you know. "And again like I said, I think play is either physically or mentally challenging yourself. And I think our society expects us to do that through like our work or our school but doesn't allow us to find ways to do it for ourselves."	*"I think moms specifically know the importance of play for their kids and therefore wanting to play with their kids and also feel this pressure to get so many things done and whatever. It's like the best thing in the world. And then I also feel that I'm not as present in that because they're playing so well together. So really working on that balance. Of yes, there are things that have to get done, but also play is important for them, for me. For us to build that relationship. But then yeah, kind of thinking about my own time, working on that. That's a work in progress that I know that I- that all moms, I'm sure- need to need to work on. But I feel like we've really been working, I've really been working on playing together and doing things together."*
"I would love to do more board games, that kind of stuff. But when?"	*"Work life balance does not happen."*
"She very much craves that like one-on-one attention. But that's where I feel like I have my moments where I like, I just don't want to play."	*"What is fun?"*

Table 3. Examples of neighborhood play spaces from each participant.

"There's a school kitty-corner to us, so there's playgrounds at the school the kids go to that they can just run across the street to use"	*"We're very lucky with three parks. I mean, I'm not even joking. Like there's one a block or two that way, and then there's a block like maybe three blocks that way. We live in a brand new like development."*
"We have a neighborhood park that's just a couple houses down and then she's got 5 or 6 houses that she can bounce between different friends. But usually they're outside. Usually, they're in the street. In the front yard. One of the families just got a trampoline. From our backyard you can see their backyard. So you see them all bouncing on the trampoline."	*"It's a reason of getting her out of the house. Let's go to the playground and She's like, OK, go for it. There's some traffic. But she's pretty… she's good listener. So I think we taught her well because we we used to - we still try to go on walks a lot – so I think we taught her like the rules of the road pretty well. She will not run on the street. She will always stop. I'm not even worried about it. Even if the ball runs, whatever goes in the street she won't run up there."*
"I just really love our neighborhood and maybe not even if it's like not inside my house. Just really love our neighborhood, we have a lot of playgrounds in walking distance and pools in walking distance."	*"Like we'll play in the driveway. I have a long driveway and she'll ride her bike up and down or her scooter, or we'll ride our bikes. Like, I'll ride my bike, she'll ride her scooter around the neighborhood. But I like our neighborhood. It's big. It's quiet."*
"Podemos ir caminando, hay una escuela cerca ya hay un playground. Dice, hay que caminar maybe como 10 minutos. O en carro. [We can go walking, there's a school nearby where there's a playground. We have to walk maybe 10 minutes. Or go in the car.]"	*"We walk in the neighborhood, we have bikes, so we ride our bikes and… there's we have wide sidewalks."*

APPENDIX 3.1

English

1. What is your first name? _____
2. What is your age? _____
3. What is your gender?
    a. Female
    b. Male
    c. Other
        i. Please describe: _____
4. Do you have at least one daughter between the ages of 6-10?
    a. Yes
    b. No
5. What is your race? (Select all that apply)
    a. Black/African American
    b. Asian/Pacific Islander
    c. White/European American
    d. Native American/Alaska Native
    e. Other
        i. Please describe _____
6. Are you Hispanic/Latinx?
    a. Yes
    b. No
7. What is your preferred language to speak?
    a. English
    b. Spanish
    c. Other
8. Has a medical professional told you that you currently should not be working out or exerting yourself for any reason (high risk pregnancy, injury, etc.)?
    a. Yes
    b. No
9. Do you have a disability that keeps you from being physically active?
    a. Yes
    b. No
10. What is your city of residence? _____
11. Do you have access to a video chat platform? (Select all that apply)
    a. Skype

b. Google Hangouts
c. Zoom
d. No/Other
    i. Please describe: _____

12. Do you have a smart phone or computer with webcam? (Select all that apply)
    a. Smartphone
    b. Tablet
    c. Laptop or Desktop with camera
    d. I do not have a device with a camera

[**IF ELIGIBLE:** You are eligible for the study. Please read the following consent form and provide your contact information so that you can be reached to schedule an interview. Please take note of any questions you may have after reading the consent form; I will be happy to answer them when we talk!
Insert consent form prior to question 13]

[**IF INELIGIBLE:** Thank you for your interest in the study. Unfortunately, you are not currently eligible for the interview. Have a great day!
Skip consent form and question 13. Survey ends]

13. Please provide your contact information (complete all that apply)
    a. Email address: _____
    b. Phone number: _____
    c. Skype username: _____
    d. Google username: _____
    e. Other: _____

Spanish

1. ¿Cuál es su primer nombre? _____
2. ¿Cuántos años tiene? _____
3. ¿Cuál es su género?
    a. Mujer
    b. Hombre
    c. Otro
        i. Por favor describa: _____
4. ¿Tiene por lo menos una hija entre las edades de 6-10?
    a. Si
    b. No
5. ¿Cuál es su raza? (Seleccione todos los que aplican)
    a. Negra/afroamericana
    b. Asiática/Indígena de las islas Pacíficas
    c. Blanca/Euroamericana
    d. Indígena de las Américas/Nativa de Alaska
    e. Alguna otra raza
        i. Por favor describa: _____
6. ¿Es usted hispana o latina?
    a. Si
    b. No
7. ¿Cuál es su idioma preferido para conversar?
    a. Inglés
    b. Español
    c. Otro
8. ¿Le ha dicho un profesional médico que actualmente no debería de hacer ejercicio o realizando esfuerzos por alguna razón (embarazo de alto riesgo, lesión, etc.)?
9. ¿Tiene una discapacidad que la previene ser activa físicamente?
    a. Si
    b. No
10. ¿En cuál ciudad vive? _____
11. ¿Tiene acceso a una plataforma de chat de video? (Seleccione todos los que aplican)
    a. Skype
    b. Google Hangouts
    c. Zoom
    d. No/Otro

i. Por favor describa: _____

12. ¿Tiene un smartphone o computadora que tenga cámara de web? (Seleccione todos los que aplican)
    a. Smartphone
    b. Tablet
    c. Computadora (laptop o desktop) con cámara
    d. Yo no tengo un aparato con cámara

[**IF ELIGIBLE:** Usted ha calificado para esta investigación. Por favor lea el siguiente formulario de consentimiento y provee su información de contacto para poder coordinar la entrevista. Por favor tome en cuenta cualquiera pregunta que tenga después de leer el formulario de consentimiento; ¡Me alegro en contestarlas cuando hablemos!
Insert consent form prior to question 13]

[**IF INELIGIBLE:** Gracias por su interés en la investigación. Desafortunadamente, usted no califica en este momento para la entrevista. ¡Tenga un buen día!

Skip consent form and question 13. Survey ends]

13. Por favor provee su información de contacto (complete todo lo que sea aplicable)
    a. Correo electrónico: _____
    b. Número de teléfono: _____
    c. Nombre de usuario de Skype: _____
    d. Nombre de usuario de Google: _____
    e. Otro: _____

APPENDIX 3.2

[After reviewing and signing consent form:]

English:

Thank you for joining me today. During this interview, I want to learn more about how you and your daughter interact in both active and non-active ways and about the activities you each do for fun. This session will be audio-recorded, and I will be taking notes so that I can accurately return to our discussion for my research. The recording will not be shared with anyone aside from my advisor. Some information you give me may be shared in my research, but your information will always be kept anonymous. You are welcome to stop me at any time for questions or if you would no longer wish to continue. You may have more than one daughter, but for the purposes of this discussion, we are going to focus on one daughter in the 6-10 age group. Do you have any questions before we begin?

First, if you'd like, you can introduce yourself by giving a pseudonym (a false name), your age, and the age of your daughter.

1. Tell me about a typical day for you (work, daycare, etc).
2. How often do you spend alone time – anywhere, doing anything – with your daughter?
3. What do you typically do in the time you spend with your daughter?
4. What do you do for physical activity, if anything?
    a. Where are you active (work, school, home, gym, outdoors, etc.)?
    b. Who are you active with (partner, friends, children, other family)?
5. How important is staying active for you?
6. What do you do for fun?
    a. Where is your favorite place to be?
    b. What are some of your favorite things (games to play)?
7. What does your daughter do for fun?
    a. Where is her favorite place to be?
    b. What are some of her favorite things (games) to play?
8. Where do you take your daughter to when you <u>both</u> want to have fun?
    a. Where does she ask to go for fun?
9. What are some examples of some games you play with your daughter?
10. Who else does your daughter play with other than you?
11. Do you think that play is important for your daughter?
    a. What about for you?
    b. Overall, is play important for children? What about for adults?
12. Tell me about an experience that you have had playing an active game with your daughter.
    a. What did you play?
    b. Who guided the play?
    c. What rules did you and your daughter put in place?
13. Describe your home/neighborhood.

   a. Any safety concerns for you/your daughter as it relates to being active in your neighborhood?

If not provided through previous answers:
1. *Do you spend time doing paid work in/out of the home?*
2. *Describe your family (size, genders, ages, etc.)*

14. Is there anything else you would like to add that you would like me to know?

Thank you! That is all for today. Please feel free to reach out if you have any questions or if you remember anything you would like to add.

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Spanish:

Hola y gracias por acompañarme hoy. Mi nombre es Ligia y soy una estudiante en UNC-Charlotte. Durante esta entrevista, quisiera aprender más sobre como usted y si hija interactúan en formas activas y no activas y también cuales actividades ustedes hacen para divertirse. El audio de esta sesión será grabado y yo estaré tomando notas para que pueda regresar a nuestra discusión de forma precisa para mi investigación. La grabación de audio no será compartida con nadie fuera de mi consejera de mi tesis. Alguna de la información que me de puede ser compartida en mi tesis, pero su información siempre será anónima. Está libre de pararme en cualquier momento para hacer preguntas o si quisiera terminar la entrevista. Puede ser que sea mas de una hija, pero para nuestra discusión, enfoquemos en solo una hija entre las edades de 6-10. ¿Tiene alguna pregunta antes que empecemos?

Primero, si le gustaría, se puede introducir con un seudónimo (nombre falso/artístico), su edad, y la edad de su hija.

1. ¿Cuánto tiempo pasa sola – en cualquier lugar, haciendo lo que sea – con su hija?
2. ¿Qué hace típicamente en el tiempo que pasa con su hija?
3. ¿Qué tan importante es ser activa para usted?
4. ¿Qué hace para actividad física, si hace algo?
   a. ¿En cuales lugares es activa (trabajo, escuela, en casa, gimnasio, afuera, etc.)?
   b. ¿Con quienes es activa (pareja, amigos, niños, otra familia)?
5. ¿Qué hace usted para divertirse?
   a. ¿Dónde es su lugar favorito para pasar tiempo?
   b. ¿Cuáles son algunas de sus cosas favoritas de hacer (juegos para jugar)?
6. ¿Qué hace su hija para divertirse?
   a. ¿Cuál es el lugar favorito de ella?
   b. ¿Cuáles son algunas de sus cosas favoritas de haces (juegos para jugar)?
7. ¿Dónde lleva su hija cuando las dos quieren divertirse?
   a. ¿Dónde pide que la lleve para divertirse?

8. ¿Cuáles son unos ejemplos de juegos que juega con su hija?
9. ¿Con quién juega su hija que no sea usted?
10. ¿Piensa que jugar es importante para su hija?
    a. ¿Y para usted?
    b. En general, ¿jugar es importante para los niños? ¿Y para los adultos?
11. Dígame sobre una experiencia que usted ha tenido jugando activamente con su hija.
    a. ¿Qué jugaron?
    b. ¿Quién dirigió el juego?
    c. ¿Qué reglas tuvieron?
12. Dígame de su hogar y vecindario.
    a. ¿Tiene preocupaciones sobre la seguridad para usted o su hija con relación a ser activas en su vecindario?

If not provided through previous answers:

1. *¿Usted pasa tiempo haciendo trabajo pagado en/fuera de su hogar?*
2. *Describa su familia (tamaño, géneros, edades, etc.).*

13. ¿Hay algo más que le gustaría contarme o que quiera que supiera?

¡Gracias! Eso es todo para hoy. Siéntase libre de comunicarse conmigo si tiene algunas preguntas o si se recuera de algo que le gustaría añadir a nuestra conversación.

CONCLUSION

It is well established that the majority of U.S. Americans across all age groups are not meeting PA recommendations, which could lead to public health issues such as increased risk of chronic disease, all-cause mortality, decreased mental health and cognition, and increased costs of healthcare (U.S. Department of Health and Human Services, 2018). This dissertation was a three-manuscript project aimed to explore evidence and inform the literature about active play and its potential to increase PA levels in both children and their adult caregivers. Together, the three manuscripts address gaps in research related to the relationship between play and parental PA as well as how play can moderate PA in parent-child dyads.

Summary of Dissertation Findings

The first manuscript aimed to summarize what is currently known about parental engagement in dyadic physical activity interventions and how play could influence their effectiveness in increasing PA levels in parents and/or children. Twenty articles describing 15 unique interventions that recruited school-aged children (aged 6-10 years) and/or their parents and measured at least parental PA were systematically reviewed. Parental engagement was through educational sessions, technology (such as text messages or study websites), or using the child as the agent of change. Interventions that were successful (identified as those where PA levels increased in either the parent or the child) were more likely to use a theory- and play-based approach. The review adds to the literature by providing support for family involvement in theory-based, playful PA interventions in parents and their school-aged children. By engaging in enjoyable interventions, participants are likely to have favorable outcomes in a PA intervention, and potentially continue building on healthy, active habits after the intervention's conclusion.

The second manuscript aimed to assess mobile apps available to children and families that promote PA and how they use play or dyadic activity. Forty-three apps from Apple's App Store met inclusion criteria, were downloaded, and reviewed for play and active play criteria as well as parental engagement. Apps often had an element of play such as competition and the ability that the activity can be freely chosen by the child/user but did not engage an additional person other than the user, indicating low promotion of dyadic play. The apps that did promote play-based physical activity with parents (or others) were often child-friendly fitness programs, active video games with the capacity for multiple players, or a simple library of dyadic or active activities. The content analysis is the first known to explore apps that may promote playful PA in parents and their school-aged children (aged 6-10 years). With screen time being a concern for sedentary behaviors, understanding how smart devices can be used through the promotion of dyadic play, active play, or PA for families is important.

The third manuscript aimed to collect mothers' perceptions, behaviors, and barriers to PA and active play in themselves, their child, and when together. Eight women were interviewed about the time they spent together with their school-aged daughters (6-10 years old) and how important play and PA were to them. While mothers placed a high level of importance on both play and PA, they expressed barriers which included other family members, work, school, or other responsibilities, and how they preferred to spend one-on-one time with their daughters. Mothers prioritized their daughters' enjoyment over their own, which minimized the importance on being physically active. When active, mothers often chose activities they enjoyed and allowed them to unwind, emphasizing that playfulness is an important component in maintaining PA habits. This study adds to the literature by focusing on a group that is at increased risk of not

meeting PA recommendations and therefore, more susceptible to health problems across the life course.

Implications for Public Health Policy and Practice

The U.S. Surgeon General recently issued an advisory on the mental-health and well-being of parents stating that adults with children experience higher levels of stress compared to other adults, which in turn affects children as well, increasing risk for depression and anxiety (HHS.gov, 2024). Physical activity is a known way to improve stress and mental health along with physical health (U.S Department of Health and Human Services, 2018). By choosing a physical activity that is enjoyable and fun, it is more likely to continue the habit, indicating that introducing play to the PA, or active play, can influence PA in parents and children. Knowing that playful interventions are effective in improving PA outcomes in parents and their school-aged children and that there are resources available and accessible via affordable smartphone apps, could aid in promoting dyadic active play and improve parent-child mental and physical health. While there are still known barriers to dyadic play and PA, incorporating playfulness can build a strong parent-child relationship and promote healthier families, thereby reducing the public health and healthcare burden that could be caused by chronic disease and poor mental health associated with physical inactivity.

Future research should continue exploring the bidirectional moderating effect play and physical activity have between each other. App and game developers should create more dyadic- or family-friendly playful activities that also incorporate both quality time and active time. PA interventions should develop playful methodologies to encourage engagement of PA for both parents and children, mainly focusing on decreasing barriers to parents, such as including activities for parents alone and for parent-child dyads to spend quality time together. Since

women and girls are less likely to meet PA recommendations, future research should further examine the barriers that are specific to mothers and daughters and interventions should focus on developing programs that foster enjoyment of PA alone and together so that women and girls build a healthy relationship with active lifestyles that can reduce those barriers and include their families.

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