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Physical activity

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Table of content

Synthesis 5

Levels of Habitual Physical Activity in Early Childhood 8
[1]DYLAN P. CLIFF, PHD, [2]XANNE JANSSEN, PHD, SEPTEMBER 2019

Physical Activity Recommendations for Early Childhood 14
RACHEL A. JONES, PHD, ANTHONY D. OKELY, EDD, FEBRUARY 2020

Correlates of Physical Activity in Early Childhood 25
TRINA HINKLEY, BA, JO SALMON, PHD, JANUARY 2011

Sedentary Behaviour Recommendations for Early Childhood 31
RACHEL A. JONES, PHD, ANTHONY D. OKELY, EDD, FEBRUARY 2020

Interventions to Promote Physical Activity in Young Children 41
STEWART G. TROST, PHD, JUNE 2020

Physical Activity, Sedentary Behaviour and Sleep in Infants, Toddlers, and Preschoolers 49
MARIEKE DE CRAEMER, PHD, VERA VERBESTEL, PHD, MARGA DECRAENE, PHD STUDENT, SOFIE NAEYAERT, PHD STUDENT, GREET CARDON, PHD, NOVEMBER 2022

Physical Activity in Early Childhood: Topic Commentary 63
JOHN J. REILLY, PHD, NOVEMBER 2022

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Synthesis

How important is it?

Child obesity is a growing problem in many nations. In 2005, the number of overweight children under the age of 5 was approximately 20 million. Despite common beliefs that children are naturally active, rates of physical activity are low in several countries. In fact, behaviours associated with a sedentary lifestyle are often common place in the daily routine of young children. Sedentary behaviours, such as television viewing and playing computer games, typically require little energy expenditure. These behaviours are not necessarily in opposition to physical activity because a child who engages in physical activity can also spend a significant amount of time in sedentary behaviours. However, given that sedentary living might have long-term negative health consequences and that physical activity is beneficial to children's health and development, it is important to find ways to encourage children to develop a healthy lifestyle from an early age.

What do we know?

Sedentary activities are often introduced early on in the infant's daily routine, and have a tendency to increase steadily from infancy to the preschool years, whereas rates of physical activity tend to be low both at home and in the childcare setting. Guidelines released in Canada and Australia, as well as those by the World Health Organization, which form part of 24-Hour Movement Guidelines, combine physical activity recommendations for the early years with recommendations for sleep and sedentary behaviour. These guidelines differ by developmental stage.

Factors associated with physical activity

Several factors are related to physical activity. Boys and girls who have active parents and who spend a lot of time outdoors are typically the most physically active. Predictors of physical activity vary depending on both the child's characteristics (e.g., age) and the settings/contexts (e.g., home vs. childcare). For example, in preschool, kindergarten and childcare settings, children are most active 1) when they play in an unconstrained environment 2) when the duration of recess is shorter, and 3) when the staff is trained to engage children in physical

activity. Providing children with play equipment that are both fixed and portable and with opportunities to engage in physical activity also increase their engagement.

Outcomes

Physical inactivity in young children is a risk factor for many health problems such as high blood pressure, weight gain, excess body fat, bad cholesterol, respiratory difficulties, cardiovascular diseases and bone health problems.

The health benefits of physical activity on child development extends much beyond physical health as it also impacts the domains of motor skills, psychological well-being, social competence and emotional maturity. In contrast, sedentary behaviours are considered to pose a threat to young children's cognitive development. Preschool children who spend too much time in front of screens are likely to experience cognitive difficulties in the school years, including attention deficits, poor language skills, low school achievement, and a short memory span (i.e., a list of items a person can retain). Specific psychosocial behaviours are also heightened as result of too much screen time. These include aggression, bullying, aggression towards siblings, peer problems, anxiety or depressive symptoms.

The total amount of time spent in front of screens also impacts young children indirectly by displacing time spent in physical activity and sleep, and by displacing more beneficial forms of sedentary behaviour (such as reading/interactions with family members). The timing of screen time also matters - for example screen time in the hour or so prior to bedtime is harmful to sleep in early childhood.

What can be done?

To encourage children to develop an active lifestyle, different organizations advise limiting the amount of time children spend in sedentary behaviours, and promoting physical activity in the family and in the childcare setting. For example, American and Australian organizations recommend that children under 2 not watch television, and that those between 2 and 5 be limited to 1 to 2 hours per day. The new guidelines (24-Hour Movement Guidelines) specify the intensity of physical activity (i.e., whether the activity is light, moderate or vigorous) for preschool aged children. Sixty minutes of moderate- to vigorous-intensity, also termed energetic play, is now recommended as part as the total 180 minutes per day. Additionally, the most recent

guidelines recommend a time for tummy time for infants (i.e., 30 minutes per day, accumulated throughout the day).

Parents can encourage their child's participation in physical activity by being role models who provide every opportunity for the child to be active, such as going for short walks instead of stroller rides, and who limit time spent in sedentary behaviours (e.g., time spent in front of screens). Parents are also responsible for providing safe and risk-free environments both indoors and outdoors where their child can be physically active. Parents should make sure to give equal opportunities to both sons and daughters to be physically active. To enhance physical activity at home, policy makers should make parental education and support a priority. As well, greater emphasis on the right to play may drive policy changes which improve levels of the 24-hour movement behaviours in early childhood. In the childcare setting, physical activity can be enhanced by integrating physical exercises of varying intensity both indoors and outdoors in children's daily routine, and by making these activities more enjoyable. As well, providing multiple short periods of free-play is a way to build on the natural tendency for children to be active at the start of free-play sessions. Children should be provided with a proper size outdoor space including shaded areas and portable equipment. Training childcare professionals in integrating physical activity within the curriculum has also been found to be a winning strategy to promote children's engagement.

Levels of Habitual Physical Activity in Early Childhood

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Introduction

Preventable lifestyle diseases continue to be major contributors to the burden of disease internationally.[1] Physical inactivity is a key contributing risk factor[2] that has a global economic burden in excess of $(INT$) 50 billion.[3] Intervention during the earliest developmental years might be required to ensure health promoting behaviours, such as physical activity, are established.[4] Despite being the most active segment of the population, monitoring studies suggest that many young children may be insufficiently active for adequate development and health.[5-8]

Subject

Physical activity is typically categorized into different intensities and is measured in metabolic equivalents (METs; 1 MET is equivalent to rest).[9] Light intensity physical activities (1.5-3.9 METs) for young children include dressing up in costumes, standing and painting, and slow walking. Moderate-to-vigorous physical activities (MVPA)(≥4 METs) include those of a higher intensity, such as running, jumping, and playing ball games. Sedentary behaviours (<1.5 METs) are those characterized by sitting or lying down, and include using electronic devices to watch entertainment programs or play electronic games, reading, and drawing. Young children's natural activity patterns are described as intermittent, and are characterized by cycles of short intense bursts of activity followed by periods of rest or lower intensity activity.[10] This activity predominantly occurs through active play[11] rather than exercise.

Physical activity has beneficial effects on health and development in the early years of life and contributes to improved motor and cognitive development, fitness, and psychosocial, cardiometabolic, bone and skeletal health.[12] Activity patterns also appear to track during

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childhood,[13] and from childhood and adolescence to adulthood,[14] suggesting that early life experiences of physical activity may shape later behaviour and subsequent health.

Although there is evidence that more physical activity is better for health, there is insufficient evidence of the precise "dose" or amount and intensity of physical activity required for adequate health and development in early childhood.[12] For this reason, the amount of physical activity specified in recommendations for infants (<1 year), toddlers (1 to 3 years) and preschoolers (3 to 4[15] or 5 years[16]) differs between the United States[17] and other countries such as Canada[15] and Australia.[16] U.S. guidelines[17] recommend that "preschool-aged children should be physically active throughout the day to enhance growth and development", but do not specify the duration or intensity of physical activity. Guidelines released in Canada[15] and Australia[16], as well as those by the World Health Organization,[18] combine physical activity recommendations for the early years with recommendations for sleep and sedentary behaviour. These guidelines, which differ by developmental stage, recommend that:

- infants (less than 1 year) who are not yet mobile should accumulate at least 30 min per day in the prone position (tummy time) spread throughout the day while awake;
- children 1-2 years of age should spend at least 180 minutes per day in a variety of types of physical activities at any intensity, including moderate- to vigorous-intensity physical activity, spread throughout the day;
- children 3-4 years of age should spend at least 180 minutes per day in a variety of types of physical activities at any intensity, of which at least 60 minutes is moderate- to vigorous-intensity physical activity, spread throughout the day.

Problems and Research Context

Difficulties in accurately measuring the unique physical activity patterns of young children have delayed progress in this area. Self-reports are inappropriate and parent-proxy reports have inherent biases.[19,20] In part, this is because young children's physical activity does not occur in easily distinguishable blocks of exercise as is typical among adults. Direct observation offers a more objective approach, however this is only appropriate for confined settings, such as the child care centre/preschool.[19,20] Accelerometers are feasible, acceptable and have adequate validity and reliability for assessing physical activity among youth, and because they collect objective, real-time data and are adequately sensitive to low intensity movements they are particularly suitable

for use with young children.[21] One limitation of accelerometry is that different cut-point definitions for defining sedentary behaviour, light physical activity and MVPA are often used in studies of young children, and the use of different definitions can have substantial effects on prevalence estimates.[22,23] Cross-validation studies have been conducted in toddlers[24] and preschoolers[25,26] in an effort to achieve consensus on the most accurate cut-point definitions for commonly used accelerometers in young children. Key Research Questions

Research using accelerometry has investigated young children's habitual physical activity levels over the course of a typical week. These studies have also attempted to quantify the amount of time preschoolers spend in light physical activity and MVPA, and have investigated compliance with physical activity guidelines.

Recent Research Results

Findings from studies using accelerometry offer important insights into young children's physical activity patterns. Studies among toddlers from Canada and Australia provided almost identical findings in that toddlers spent approximately 60 minutes per day in MVPA and approximately 240 minutes per day in light physical activity.[5,6] Consequently, 97%-99% of toddlers met physical activity guidelines of at least 180 min per day of physical activity of any intensity.[5,6]

Studies in preschool children have been less consistent. Using similar methods to those used among toddlers, one Australian study reported that 3- to 5-year-old preschoolers spent approximately 100 minutes per day in MVPA and approximately 270 minutes per day in light physical activity.[8] In that study, 93% of preschoolers met the physical activity guideline of at least 180 min per day of physical activity including at least 60 min of MVPA.[8] In contrast, a nationally-representative study of Canadian 3- to 4-year-old preschool children used different methodologies for assessing physical activity and reported that children spent approximately 68 minutes per day in MVPA and approximately 210 minutes per day in light physical activity.[7] In that study, 62% of preschoolers met the physical activity guideline of at least 180 min per day of physical activity including at least 60 min of MVPA.[7] Methodological issues, such as the application of different measurement instruments and the use of different definitions for physical activity intensities are likely to contribute to this variation between studies[8] and continue to influence our understanding of physical activity patterns during the early years.

Research Gaps

To our knowledge, only Canada has nationally-representative accelerometer data among 3- to 4-year-old children to describe levels of objectively-measured physical activity. National monitoring surveys are urgently needed to understand more precisely how active young children are, and to ascertain the proportion of the early childhood population achieving the recommended amount of physical activity each day. Very little data are currently available for children under 3 years of age, and it is unclear if specific socio-demographic groups are in particular need of support to meet guidelines. Despite the existence of guidelines, there is not yet consensus on the precise amount and intensity of physical activity required for optimum health and development in the early years, resulting in different recommendations in different countries. Thus, research on the relationships between objectively measured physical activity and developmental and health outcomes is still needed.

Conclusions

Physical activity plays an important role in young children's health and development, however contemporary lifestyles and environments appear to be preventing some young children from engaging in adequate levels of physical activity. As the origins of an active lifestyle begin in the early years of life, physical inactivity during early childhood has consequences for children's current and future health, behaviour, social and emotional development, and cognitive function.

Implications for Parents, Services and Policy

Influential people and institutions in the lives' of young children must ensure they receive adequate opportunities to engage in the recommended amount of developmentally-appropriate and health-enhancing physical activity. This should occur through unstructured active play and structured learning experiences, in the home and child care centres, through active transportation, and in socially- and culturally-accepted and enjoyable ways. National surveillance systems are required to accurately describe children's activity levels and patterns during the early years and to determine if targeted interventions are required for specific segments of the population.

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Physical Activity Recommendations for Early Childhood

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Introduction

Early childhood (0-5 years) is a critical time for the development of healthy behaviours, such as physical activity.[1] Participation in regular physical activity from birth prevents short- and long-term health complications, such as overweight and obesity, cardiovascular disease and musculoskeletal health.[2-4] Furthermore, the promotion of physical activity should start as early as possible as physical activity levels track from early childhood to childhood and adolescence.[5]

Subject and Research Context

Given the international trend of less than optimal physical activity levels among young children, several countries have recently developed physical activity recommendations for the Early Years.[6-10] Additionally, the World Health Organization has developed physical activity recommendations for children aged birth to 5 years.[11] These recommendations are evidence-based and provide a guide for how much and what type of physical activity is appropriate for infants (birth-1 year), toddlers (1-3 years) and preschool aged children (3-5 years). The majority of the guidelines also recognize the importance of adequate sleep (in conjunction with physical activity and sedentary behaviours (specifically screen time) and are operationalized as 24-hour Movement Guidelines.[6-8,10] All physical activity guidelines support the notion that physical activity is a natural and life-long activity that should be encouraged from birth. Parents and/or caregivers are encouraged to be positive role models and provide daily physical activity opportunities incorporating developmentally appropriate activities. Both structured and unstructured physical activity opportunities should be spread throughout the day and be provided in safe indoor and outdoor environments and the emphasis should be on “fun” and “participation” rather than competition.

Key Research Questions

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The aim of this chapter is to summarize the empirical research supporting recently developed physical activity recommendations, in multiple countries, for children birth to 5 years of age.

The key research questions addressed in this chapter are:

1. What is the current evidence supporting the association between physical activity and health outcomes in early childhood?
2. Based on the current evidence, how much time should young children spend in physical activity and what type of physical activity should young children participate in.

Current evidence

Canada was one of the first countries to update their physical activity guidelines for children aged 0-5 years.[7] Researchers involved in the development of these guidelines published a comprehensive systematic review which investigated the associations between physical activity and health-related outcomes.[12] This systematic review provides an excellent summary of the latest evidence.[12] Studies included in the review varied significantly in design and sample size and included randomized controlled trials, cross-sectional studies and longitudinal studies.[12] This chapter provides an overview of data presented in the review, as well as providing updated evidence since publication of the review. The association between physical activity and several health outcomes, namely, adiposity, motor development, psychosocial health, cognitive development, fitness, bone and skeletal health and cardiometabolic health are reviewed.

Fifty-seven studies investigated the relationship between physical activity and adiposity. Mixed results were reported with some studies reporting significant relationships between physical activity and adiposity and others reporting no relationships. Mixed findings were reported irrespective of the design of the study. For example, of the 40 cross sectional studies, physical activity was positively associated with adiposity in 12 studies[13-24] and of the seven longitudinal studies physical activity was positively associated with adiposity in three studies.[25-27] For all studies the relationship was stronger if a more direct measure of adiposity was used, for example, percent body fat as opposed to body mass index. The methodological quality of the studies, irrespective of design, was deemed as low or very low. Twenty-three studies investigated the association between physical activity and motor development. Seventy five percent of randomized controlled trials (n=4) reported positive associations[28-30] as did 50% of clustered randomized controlled trials (n=2),[31] 70% of cross-sectional studies (n=10)[15,32-37] and 83% of the

non-randomized interventions (n=6).[38-42]

In the Canadian systematic review,[12] less than 15 studies reported on the associations between physical activity and psychosocial health and cognitive development and less than 10 studies reported on the associations between physical activity and fitness, bone and skeletal health and cardiometabolic health. Two randomized controlled trials reported greater increases for psychosocial health outcomes in the intervention group compared to the control group[28,43] and among the two longitudinal studies, physical activity, assessed as sport participation, was positively associated with psychosocial health in one study.[44] The association between physical activity and cognitive development were mixed. For the clustered randomized controlled trials (n=4), significant positive associations between physical activity and cognitive development were reported.[45-48] These four studies had high methodological quality. Physical activity was positively associated with fitness in all studies (n=3).[14,25,49] The majority (83%, 5/6) of cross-sectional studies reporting the association between physical activity and bone and skeletal health identified significant associations.[50-54] Nine studies assessed the association between physical activity and cardiometabolic health. Mixed results were reported for studies investigating the relationship between blood pressure, cholesterol or triglycerides in both longitudinal studies and cross-sectional studies.[26,55]

In summary, there is now more convincing evidence to suggest that physical activity of at least moderate- to vigorous-intensity is consistently associated with better health indicators.[13,14,56,57] Furthermore, the evidence pertaining to younger children (0-2 years) has increased thus highlighting the importance of participating in physical activity from birth. Based on these findings the following guidelines were recommended (Table 1). The new guidelines specify the intensity of physical activity (i.e., whether the activity is light, moderate or vigorous) for preschool aged children. Sixty minutes of moderate- to vigorous-intensity, also termed energetic play that results in ‘huff and puff’ is now recommended as part of the total 180 minutes per day.[6-11] Additionally, the most recent guidelines recommend a time for tummy time for infants (i.e., 30 minutes per day, accumulated throughout the day).

Table 1: Country-specific physical activity recommendations for children birth to five years

Country	Infants	Toddlers	Preschoolers

Australia* (released 2017) Infants: 0-1 year Toddlers: 1-3 years Preschoolers: 3-5 years[6]	Be physically active several times in a variety of ways, particularly through interactive floor-based play; more is better. For those not yet mobile, this includes at least 30 minutes of tummy time spread throughout the day while awake.	At least 180 minutes spent in a variety of physical activities including energetic play, spread throughout the day; more is better.	At least 180 minutes spent in a variety of physical activities, of which at least 60 minutes is energetic play, spread throughout the day; more is better.
Canada* (released 2017) Infants: 0-1 year Toddlers: 1-2 years Preschoolers: 3-4 years[7]	Be physically active several times in a variety of ways, particularly through interactive floor-based play—more is better. For those not yet mobile, this includes at least 30 minutes of tummy time spread throughout the day while awake.	At least 180 minutes spent in a variety of physical activities at any intensity, including energetic play, spread throughout the day—more is better.	At least 180 minutes spent in a variety of physical activities spread throughout the day, of which at least 60 minutes is energetic play—more is better.
New Zealand* (released 2017) Recommendations for specific ages groups not provided[8]	Provide fund activities the support physical, social, emotion and spiritual grown (at least three hours every day for toddlers and preschoolers, spread throughout the day). Include plenty of opportunities for active play: that develop movement competence and confidence; that provide sufficient challenges to build resilience and encourage creativity through exploration; where children are by themselves as well as interacting with others, such as parents, siblings, friends, whanau/family and other caregivers that include a variety of indoor and outdoor activities, especially activities involving nature.		

United Kingdom (released 2019) Infants: 0-1 year Toddlers: 1-2 years Preschoolers: 3-4 years[9]	Babies should be encouraged to be active throughout the day, every day in a variety of ways, including crawling. If they're not yet crawling, encourage them to be physically active by reaching and grasping, pulling and pushing, moving their head, body and limbs during daily routines, and during supervised floor play. Try to include at least 30 minutes of tummy time spread throughout the day when they're awake. Once babies can move around, encourage them to be as active as possible in safe and supervised play environments.	Toddlers should be physically active every day for at least 180 minutes (3 hours). The more the better. This should be spread throughout the day, including playing outdoors. The 180 minutes can include light activity such as standing up, moving around, rolling and playing, as well as more energetic activity like skipping, hopping, running and jumping. Active play, such as using a climbing frame, riding a bike, playing in water, chasing games and ball games, is the best way for this age group to get moving.	Pre-schoolers should spend at least 180 minutes (3 hours) a day doing a variety of physical activities spread throughout the day, including active and outdoor play. The more the better. The 180 minutes should include at least 60 minutes of moderate-to-vigorous intensity physical activity. Children under 5 should not be inactive for long periods, except when they're asleep. Watching TV, travelling by car, bus or train, or being strapped into a buggy for long periods are not good for a child's health and development.

South Africa* (released 2018) Infants: 0-1 year Toddlers: 1-3 years Preschoolers: 3-5 years[10]	Be physically active several times a day in a variety of ways through interactive floor-based play, including crawling. For babies not yet mobile, this included at least 30 minutes of tummy time spread throughout the day while awake, and other movements such as reaching and grasping.	At least 180 minutes spent in a variety of physical activities including energetic play, spread through the day, more is better.	At least 180 minutes spent in a variety of physical activities of which at least 60 minutes is energetic play that raises heart rate and makes children “huff and puff” (i.e., running, jumping, dancing), spread throughout the day, more is better
World Health Organization* (released 2019) Infants: 0-1 year Toddlers: 1-2 years Preschoolers: 3-4 years[11]	Be physically active several times a day in a variety of ways, particularly through interactive floor-based play; more is better. For those not yet mobile, this includes at least 30 minutes in prone position (tummy time) spread throughout the day while awake.	Spend at least 180 minutes in a variety of types of physical activities at any intensity, including moderate-to-vigorous-intensity physical activity, spread throughout the day; more is better.	Spend at least 180 minutes in a variety of types of physical activities at any intensity, of which at least 60 minutes is moderate- to vigorous intensity physical activity, spread throughout the day; more is better.

*Included as part of 24-hour Movement behavior Guidelines

Research Gaps

Since the release of the revised country-specific physical activity recommendations, substantial international collaborative work has continued to address the research gaps. For example, surveillance studies which assess the proportion of children who meet the recommendations are

currently underway. The SUNRISE study is currently investigating this in 31 countries; two thirds of which are low- or middle-income countries. Data collection for the pilot study will be completed in 2020 (https://sunrise-study.com). Simple well-designed interventions have been reported, for example a recent study showed that by increasing the number of scheduled outdoor times in early childhood education and care settings, children spent significant more time in moderate- to vigorous-intensity physical activity.[58] Further innovative studies are called for to ensure optimal levels of physical activity are achieved.

Additional studies monitoring the awareness and uptake of the recommendations by stakeholders such as health professionals, childcare workers and parents are needed, however this type of investigation is often hindered by difficulty in securing funding. There have been small gains in this area, with some countries successfully increasing awareness of the recommendations among key stakeholders, however progress is generally slow.

Many studies which provided the evidence for the revised country-specific guidelines were low methodological quality. Based on the GRADE framework, in the Carson review,[12] only a few studies were deemed to have moderate or high methodological quality.[28,45] It is important that all studies are methodologically sound to ensure the most robust evidence is provided which will in turn better inform policy and practice.

Conclusions

Life-long physical activity habits need to be established in the first five years of life as participation in regular physical activity has many health benefits. The release of a number of country-specific physical activity recommendations in the last five years provides clear recommendations on the appropriate type, intensity and amounts of physical activity for young children. Adhering to such recommendations will enhance health outcomes for children and provide the best possible start. Establishing healthy physical activity habits from a young age, through adherence to evidence-based physical activity recommendations, will be beneficial.

Implications for Parents, Services and Policy

The development of physical activity recommendations for children from birth to 5 years will have several notable implications for parents, services and policy makers. Current prescriptive physical activity recommendations, which are based on solid empirical evidence, will:

1. Assist key stakeholders to understand the importance of physical activity for health benefits among young children;

2. Inform government policy in relation to health-promoting physical activity for children birth to 5 years of age;

3. Assist consumers, childcare workers and other health professionals to understand the importance of physical activity for health in children; and

4. Underpin and support health promotion activities and intervention by workers across a range of sectors and all levels of government.

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Correlates of Physical Activity in Early Childhood

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Introduction

Physical activity is important for many health outcomes. In young children, physical activity has been negatively associated with weight status[1-3] and blood pressure,[4] and beneficial for bone health.[5] Physical activity during the early childhood period is also important as that is the time when children can learn and develop healthful behaviours,[6-7] such as physical activity, which can then support them throughout their lives. As discussed in the other papers on this topic, the amount of physical activity young children participate in varies widely across studies.[8-13] This suggests that some children may not have the opportunities or support they need to be active. It is therefore imperative to understand the correlates of, or factors which might influence, physical activity in early childhood so that support can be given to those children in need.

Subject

Correlates of physical activity in young children have been identified across a number of settings and contexts. For instance, characteristics of the child's demographic and biological characteristics, social and physical environments have all been shown to be associated with young children's physical activity.[14] Developing knowledge of such correlates is necessary so that interventions to increase physical activity can target those factors.

Problems

Until recently, it was generally assumed that young children were "naturally physically active." In the last 10 years or so, it has become evident that many young children do not participate in sufficient physical activity for health. Research has begun to emerge about the correlates of physical activity in young children.

Young children spend their time in a range of different settings and contexts. This includes the home with parents or other adults, child care settings with trained or untrained staff, preschool

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or kindergarten environments where they may be exposed to a variety of different programs, and local neighbourhood environments such as playgrounds and shopping centres. The correlates which might influence physical activity behaviours also vary across those settings and contexts. For instance, in the home environment having someone to play with might be important, whereas at preschool having more outdoor space might help to support physical activity. Identifying correlates across those settings is challenging, and compounded by the child's inability to accurately self report given their young age and lack of cognitive development. Parents may report on behalf of the child, however, there may be large amounts of time where the child is not in the parent's company (for instance, while the child is at preschool, kindergarten or child care) and therefore the parent is unable to report on the child's behaviour or potential correlates during those periods.

Compounding the identification of physical activity correlates is the diversity of measurement methods which have been employed to measure physical activity in young children. They include direct observation, parent-proxy report, *accelerometry* and pedometry. These instruments measure different aspects of physical activity and therefore differences in identified correlates may be evident.

Research Context

Correlates of physical activity are often studied in cross-sectional studies. That type of study design does not allow researchers to make conclusions about causality, that is, researchers cannot definitively state that the correlate being studied directly influences physical activity, only that it is associated with the behaviour. Additionally, many studies which investigate correlates of physical activity in young children use relatively small samples, often fewer than 300 children, and investigate a small range of potential correlates. As preschool children may be active across a range of environments, it is also important to identify potential correlates in those environments. More recently, a few cohort studies have begun to emerge. Such studies allow the same group of children to be followed over a period of time, and researchers can then make more appropriate conclusions about causality between correlates and behaviour.

Key Research Questions

Key questions include identifying which contexts or settings correlates may operate in, which factors within each of those contexts or settings might be important, and whether correlates vary

by characteristics of the child, such as sex, ethnicity or weight status.

Recent Research Results

A recent review of the correlates of young children's physical activity reported that young children are more active if: they are boys, their parents participate in physical activity and are active with their child, and they spend more time outside.[14] Age was found to have no association with young children's physical activity.[14] Although a total of 39 potential correlates had been examined, most had been investigated in too few studies to be able to draw conclusive findings.

Other recent research has investigated the environment at preschools, kindergartens and child care centres. For instance, studies have reported that the ground surface (i.e., grass, asphalt, etc), pathways, play structures and open spaces have been shown to correlate with physical activity.[15] Fewer children per square metre of outdoor space, shorter recess time,[16] active opportunities, fixed and portable play equipment, and staff trained in physical activity for young children[17] have also been found to promote physical activity.

Research Gaps

Little is known about social influences on young children's physical activity. For instance, does parent encouragement and logistic support correlate with higher levels of physical activity in young children as it does for older children? Similarly, with the exception of time outside, little is known about how other child behaviours, such as television viewing or other screen-based behaviours, might influence their physical activity. Cohort and intervention studies are required to identify the direction of causality of potential correlates. As research in this area has primarily relied on small, cross-sectional studies, primarily in the United States and the United Kingdom some potentially important correlates may have not yet been identified. Additionally, using objective measures of physical activity and standardized protocols for analyzing and interpreting data would aid in comparability of findings across studies. A more comprehensive understanding of children's innate psychological and cognitive drives, although difficult to capture in such a young population, may also facilitate a more comprehensive understanding of children's behaviours and support individual level intervention strategies. Virtually no research has been undertaken in children younger than 3 years of age.

Conclusions

Although physical activity is important for health and development of young children, not all children are meeting the physical activity recommendations. There is consistent evidence that boys are more active than girls, that parents who support and participate in physical activity with their child have more active children, and time spent outdoors is associated with higher levels of physical activity. Further research that follows changes in children's physical activity as they age and examines factors that influence these changes is required. Very few intervention studies that assess the effectiveness of strategies to promote young children's physical activity have been tested, particularly among children younger than 3 years.

Implications for Parents, Services and Policy

Implications for parents

- Young children need parents' and other adults' support to access environments where they can be physically active.
- Young children need to spend time outdoors. Ideally, this should be several hours every day.
- Parents should model healthy physical activity behaviours by being active themselves and also interacting with their children in physical activities such as bike riding, walking and active play.
- Parents need to be aware that their daughters need to spend just as much time and energy being physically active as their sons.

Implications for services

- Preschools, kindergartens and child care centres should be encouraged to provide children with ample time outdoors on a daily basis.
- If inclement weather inhibits active outdoor play, centres should ideally provide children with opportunities to be active indoors.
- Staff should be educated and provided with training in young children's physical activity, including appropriate activities and strategies to support healthy levels of physical activity for the children in their care.
- Girls may need gender-appropriate opportunities to be active, as research shows that they are consistently less active than their male counterparts.

- Physical environments at centres should include a range of activity opportunities to support children's physical activity including a variety of portable and fixed play equipment and adequate shading.

Implications for policy

- Establishing programs to raise awareness of the factors which parents and other care-givers can utilize to support young children's physical activity should be a national priority for every country.
- Governmental policies covering preschools, kindergartens and childcare centres should include requirements for minimum amounts of time outside as well as evidence-based programs which support physical activity, with a particular focus on gender-specific activities to ensure that girls also engage in healthful levels of physical activity.

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Sedentary Behaviour Recommendations for Early Childhood

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Introduction

Early childhood (defined as 0-5 years) has been identified as a critical time in the development of sedentary behaviours as data shows that these behaviours track strongly into childhood and adolescence.[1,2] Some sedentary behaviours are important for healthy child development (e.g., play-based activities). These are not the focus of this updated review. This review is more concerned with sedentary behaviours, such as screen time – inclusive of television watching, use of electronic media and use of tablets and phones – as this is where most of the evidence exists. It is also important to note that sedentary behaviour is not the opposite of physical activity; that is, just because a child is physically active does not mean he/she does not spend excessive time in sedentary behaviours.

In recent years, a number of countries and organizations have released sedentary behaviour recommendations for the early years (0-5 years).[3-7] Such recommendations have been informed by current evidence pertaining to the relationship between health and developmental outcomes and sedentary behaviour in this age group and the "dose" of sedentary behaviour above which these health consequences become more pronounced. For some countries these guidelines form part of 24-Hour Movement Guidelines, which are inclusive of physical activity, sedentary behaviour and sleep.[4,5,6]

Subject and Research Context

Sedentary behaviour is defined as behaviours that encompass sitting or lying as the dominant posture and result in very low levels of energy expenditure.[8] They are multi-faceted and include screen time (television, DVD, computer, tablet and mobile phone), motorised transportation, and sitting to read or complete homework.[8] The majority of sedentary behaviour research in young children has focused on television viewing. While this is an important sedentary behaviour, it is only one of a range that can be undertaken. It is becoming increasingly clear that it is the total

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time spent in sedentary behaviour, and the length and number of the bouts spent being sedentary, that are important risk factors for health in adults[8,9] and adolescents.[10,11] As such, it is important to examine the health evidence for this behaviour in early childhood and to make recommendations for parents, service planners and providers and policy makers within the early childhood sector.

Problems and Key Research Questions

The aim of this chapter is to summarize the evidence which has informed the development of current global and country-specific sedentary behaviour recommendations for children aged 0 to 5 years.

The key research questions addressed in this chapter are:

1. What is current evidence highlighting associations between health and developmental outcomes in early childhood and sedentary behaviours?
2. Based on the evidence, how much time should young children spend in specific sedentary behaviours?
3. Do these recommendations differ for different stages of early childhood (infants, toddlers, and preschoolers)?

Recent Research Results

Evidence reporting on associations between sedentary behaviour and health and developmental outcomes (inclusive of adiposity, motor development, psychosocial health, cognitive development, cardiometabolic health, fitness and bone and skeletal health) has increased several -fold over the last decade. Associations between sedentary behaviour and health and development outcomes have been succinctly summarized in a recent review by Poitras et al.[12] A total of 96 studies were included in the review.[12] Overall, there is enough evidence to suggest that screen time (measured largely as television viewing time) is either not beneficial or negatively associated with children's health and developmental outcomes, namely adiposity, motor development, cognitive development and psychosocial health. Most studies in the review reported on the relationship between sedentary behaviour and adiposity (n=60, 63%).[12] Of the 10 longitudinal studies that reported the relationship between television time and adiposity, six (60%) studies reported negative associations.[13-18] Cross sectional evidence found that total screen

time was negatively associated with adiposity.[19-23] Television watching was negatively associated with motor skill development; children who were frequently exposed to television were more likely to have delayed motor skill development.[24] Of the studies that reported associations between television viewing and psychosocial outcomes more than half reported negative associations. Furthermore, several studies reported specific psychosocial behaviours which were heightened as result of the television viewing. These included aggression,[25] bullying,[26] aggression towards siblings,[27] peer-problems,[28] anxiety or depressive symptoms.[29,30] Negative associations between screen time and cognitive development have also been reported in a number of studies, including both longitudinal studies[18,28,29,31,32] and cross-sectional studies.[24,33,34,35] The current evidence pertaining to the association between sedentary behaviour and bone and skeletal health, fitness and cardiometabolic health is not developed enough therefore definitive conclusion cannot be made.

Based on the evidence provided, and consensus among experts, the following global and country-specific sedentary behaviour recommendations for early childhood have recently been published.

Table 1: Global and country-specific sedentary behaviour recommendations for children birth to five years

Country	Infants	Toddlers	Preschoolers

World Health Organization* (updated 2019) Infants: 0-1 year Toddlers: 1-2 years Preschoolers: 3-4 years[3]	Not be restrained for more than 1 hour at a time (e.g., prams/strollers, high-chairs, or strapped on a caregiver's back). Screen time is not recommended. When sedentary, engaging in reading and storytelling with a caregiver is encouraged.	Not be restrained for more than 1 hour at a time (e.g., prams/strollers, high-chairs, or strapped on a caregiver's back) or sit for extended periods of time. For 1-year-olds, sedentary screen time (such as watching TV or videos, playing computer games) is not recommended. For those aged 2 years, sedentary screen time should be no more than 1 hour; less is better. When sedentary, engaging in reading and storytelling with a caregiver is encouraged.	Not be restrained for more than 1 hour at a time (e.g., prams/strollers) or sit for extended periods of time. Sedentary screen time should be no more than 1 hour; less is better. When sedentary, engaging in reading and storytelling with a caregiver is encouraged.

Australia* (released 2017) (0-5 years) Infants: 0-1 year Toddlers: 1-3 years Preschoolers: 3-5 years[4]	Not being restrained for more than 1 hour at a time (e.g., in a stroller, car seat or high-chair). Screen time is not recommended. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.	Not being restrained for more than 1 hour at a time (e.g., in a stroller, car seat or high-chair) or sitting for extended periods. For those younger than 2 years, sedentary screen time is not recommended. For those aged 2 years, sedentary screen time should be no more than 1 hour; less is better. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.	Not being restrained for more than 1 hour at a time (e.g., in a stroller or car seat) or sitting for extended periods. Sedentary screen time should be no more than 1 hour; less is better. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.
Canada* (released 2016) (0-4 years) Infants: 0-1 year Toddlers: 1-2 years Preschoolers: 3-4 years[5]	Not being restrained for more than 1 hour at a time (e.g., in a stroller or high-chair). Screen time is not recommended. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.	Not being restrained for more than 1 hour at a time (e.g., in a stroller or high-chair) or sitting for extended periods. For those younger than 2 years, sedentary screen time is not recommended. For those aged 2 years, sedentary screen time should be no more than 1 hour—less is better. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.	Not being restrained for more than 1 hour at a time (e.g., in a stroller or car seat) or sitting for extended periods. Sedentary screen time should be no more than 1 hour—less is better. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.

New Zealand (released 2017) Recommendations for specific ages groups not provided[6]	Provide regular activity breaks to limit the amount of time a child spends sitting. Discourage screen-time for under-two-year-olds and limit screen time to less than one hour every day for children aged two years or older- less is best. Limit time in equipment that restricts free movement.		
South Africa* (released 2018) Infants: 0-1 year Toddlers: 1-3 years Preschoolers: 3-5 years[7]	Engaging in stimulating activities with a caregiver, such as playing with safe objects and toys, having baby conversations, singing and storytelling. Babies should NOT be strapped in and unable to move for more than 1 hour at a time (e.g., in a pram, high-chair, or on a caregiver's back or chest) while awake. Screen time is NOT recommended.	Engaging in activities that promote development, such as reading, singing, games with blocks, puzzles, and storytelling with a caregiver. Toddlers should NOT be strapped in and unable to move for more than 1 hour at a time (e.g., in a pram, high-chair or strapped on a caregiver's back or chest) and should not sit for extended periods. For toddlers younger than 2 years, scree time is NOT recommended. For toddlers aged 2 years, screen time should be no more than 1 hour, less is better.	Engaging in activities such as reading, singing, puzzles, arts and crafts and storytelling with a caregiver and other children. Preschooler should not be strapped in or unable to move for more than 1 hour at a time and should not sit for extended periods. Screen time should be no more than 1 hour per day, less is better.

*Included as part of 24-hour Movement behavior Guidelines

Research Gaps

Despite the increase in the number of studies investigating associations between sedentary behaviour and health and developmental outcomes, there are still several gaps in the current research that need further investigation. These include:

1. Is the relationship between sedentary behaviour and health mediated by other associated health behaviours such as an increase in energy intake as a result of increased snacking and exposure to food advertising?
2. Does sedentary behaviour displace physical activity or sleep?
3. Is the relationship between sedentary behaviour and fatness mediated by participation in moderate-to-vigorous intensity physical activity? Few studies to date control for physical activity and sleep, and these are independent behaviours not necessarily inversely correlated with one another, it is not known if the relationships that have been found between sedentary behaviour and some of the outcomes are a result of higher levels of sedentary behaviour or lower levels of physical activity or sleep or both.
4. It is not possible to determine if the amount of time spent sitting watching television or the content of the programs viewed is what explains the relationship between television viewing and some cognitive and self-regulation outcomes.

In addition:

1. More high-quality evidence from experimental and longitudinal studies which have a measure of sedentary behaviour during early childhood is needed.
2. More studies that use an objective measure of sedentary behaviour such as accelerometry or inclinometry are needed when examining overall time spent in sedentary behaviour or sitting.
3. Most of the evidence is for television viewing. More evidence is needed on the relationship of other sedentary behaviours, especially electronic media use, mobile phones and tablets, with health and developmental outcomes.

Conclusions

For children aged 2 to 5 years, spending more than two hours per day watching television or using other electronic media or hand-held devices may be detrimental to a wide range of health, developmental and educational outcomes. As time spent in sedentary behaviour (especially screen time) increases as young children transition into formal schooling[36] and throughout childhood and adolescence.[37,38] It is important to minimize time spent in these behaviours prior to school to maximize compliance with the recommendations for school-aged children of no more than two hours of screen time per day. For children under two, there is no evidence that

watching television or using electronic media/hand-held devices has educational or health benefits; moreover, there is some evidence that it may delay or reduce some cognitive outcomes such as language and word vocabulary. Children aged 0-5 should not be sedentary or restrained (i.e., in a stroller, car seat or high-chair) for more than one hour at a time, except while sleeping. This includes any situation where the child is predominantly inactive (i.e., not standing up or moving).

Implications for Parents, Services and Policy

To assist parents, service providers and policy makers in meeting the recommendations around television and other electronic media, it is advised to not have televisions or game consoles in children's bedrooms or child care centres, not eat meals in front of the television, and to turn the television off when it is not being watched. Parents and service providers should also set limits and rules for their own viewing as well as for children to role model correct behaviours to children.

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Interventions to Promote Physical Activity in Young Children

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Introduction

Adequate participation in physical activity during early childhood is considered essential for normal growth and development.[1,2] Physical activity is also an important contributing factor in the prevention of overweight and obesity in young children.[1,2] In recognition of the importance of regular physical activity, national guidelines issued recommend all children from birth to age five engage in daily physical activity that promotes health-related fitness and movement skills.[3] Similar recommendations that integrate movement behaviours across a 24 hour-period have been issued by clinicians, researchers and early childhood education stakeholders in Canada,[4] Australia[5] and the United Kingdom.[6] Yet, despite the importance of regular physical activity, objective monitoring studies conducted in North America, Australia and the United Kingdom suggest that less than half of young children meet physical activity recommendations related to participation in daily moderate-to-vigorous physical activity.[7,8]

Subject

The widespread problem of physical inactivity, taken alongside the continued rise in the prevalence of obesity in children under the age of 5, underscores the need for effective but readily translatable policies and programs to promote physical activity in young children. This brief provides an updated review to summarize current knowledge on interventions to promote physical activity in early childhood settings.

Problem

Despite there being an increased number of rigorously evaluated interventions to promote physical activity in children aged 5 years and under, there remains inconsistent evidence of their effectiveness. The scientific evidence to advise policy makers, service planners and providers

suggests that educator led physical activity interventions delivered in centre-based childcare settings may be effective in increasing movement competence and physical activity. However, variations in intervention delivery, fidelity, evaluation methodologies and study outcomes make it difficult to provide explicit recommendations about what works or doesn't work, when it comes to getting young children more physically active.

Research Context

A large percentage of children under the age of 5 are in some type of regular child care arrangement,[9] intervention studies have, therefore, been primarily implemented and tested in center-based early childhood education settings.[10-12] Notably, however, physical activity interventions targeting other types of childcare settings such as family child care homes, and those including parental involvement, are emerging in the research literature with greater regularity.[13-17]

Key Research Questions

Published studies in this area have primarily addressed the question of whether curricula emphasizing structured physical activity, movement skill training or reductions in screen time are effective at increasing physical activity. Other studies have investigated the impact of environmental or policy changes on physical activity levels during childcare.

Recent Research Results

A growing number of studies have employed experimental study designs to evaluate interventions to increase physical activity in young children. Sixteen studies tested the effectiveness of specialized physical activity curricula or movement training programs.[18-33] Nine additional studies tested multi-component interventions targeting physical activity promoting policies and practices strategies,[34-40] including the effects of increasing free-play opportunities during child care attendance.[41,42]

Of the 16 trials testing curriculum-based approaches, activities ranged from highly prescriptive exercise training regimens (jumping, hopping, skipping, circuit training) to developmentally-appropriate, physically active imagination games.[18-33] Eight of these investigations included strategies to improve fundamental movement skills.[19,22,24,26,27,32] Childcare staff, research staff/experts or a combination of both implemented the planned activity sessions or lessons.

Children participated in the intervention activities lessons for as little as 10 to 60 minutes between two and five days per week. The duration of these interventions ranged from 2 days,[25,36] 4- to 8-weeks,[28,31] between 3 and 5 months[18,19,24,26,27,30] and longer interventions of 6 to 18 months.[22,23,37] Accelerometers were used to measure physical activity in 10 of the studies, with nine using count cut offs to categorize time spent in different physical activity intensity levels.[22,23,25,27-31,33] Data collection times included, during child care hours,[21,27,28,33] total daily activity2[2,31] or combinations of both.[23,25,29,30]

Of the 16 trials, 10 reported significant increases in physical activity level [21,25,27-30] or significant improvements in fundamental movement skills.[22-24,32] These studies were highly structured interventions that involved repetitive physical activity regimes performed by trained childcare staff who received professional development and ongoing support to implement the programs.

The nine studies that evaluated environmental or policy interventions to promote physical activity have reported mostly positive findings.[34-42] Five studies incorporated modifications to the built environment or outdoor playtime,[34,36-38,41,42] 2 studies included parent involvement,[37,38] and 5 studies incorporated staff training or facilitated feedback to increase implementation of physical activity promoting policies.[35,37,38,40,42] The interventions ranged from 2-5 days,[34,36,39] 8-weeks to 6 months[35,37,38,40-42] and 12 months.[39] One ongoing study plans to report outcomes after 18 months.[40] Eight studies used accelerometers to measure physical activity via count cut offs to categorize time spent in different physical activity intensity levels.[34-38,40-42] Data collection times included during childcare[34,35,37,40,42] and total daily activity.[36,38,41] Significant increases in objectively measured daily physical activity were seen in 5 studies where a focus was primarily on the addition of portable playground equipment, providing multiple bouts of unstructured play, and training teachers to incorporate physical activity into regular learning experiences in literacy, numeracy, and science.[34,35,38,41,42]

Research Gaps

To advance our understanding in this area, some key research questions would include: 1) What are the key behavioural settings for promoting physical activity in young children? 2) Are programs to promote movement or physical activity in infants and toddlers warranted, and if so, what settings and strategies would be effective? 3) Are modifications to the childcare environment such as incorporating natural playground design and improving service provider's physical activity leadership skills effective in increasing physical activity in young children? 4)

Are structured physical activity programs led by physical education specialists or community-based physical activity providers feasible, sustainable, and effective in promoting physical activity in other behavior settings? 5) How can childcare providers engage and motivate parents and other caregivers to promote and support physical activity at home?

Conclusions

There is now a significant number of studies examining the effectiveness of interventions to promote physical activity in young children. Overall, the evidence suggests that physical activity interventions implemented in early childhood education and care settings are effective at improving child physical activity levels. The challenge now is determining how such programs can be scaled up and implemented as routing practice in early childhood settings.

The available evidence, although still limited, suggests that simple modifications to the outdoor play environment such as modified outdoor playtime schedules and the provision of “off the shelf” portable play equipment can increase physical activity behaviour. Additionally, training teachers to incorporate movement into the standard classroom curriculum appears to be effective in increasing physical activity levels during the preschool day. However, providing multiple short bouts of free-play capitalizes on the natural tendency for children to be active at the start of free-play session, and may be a simple option of changing policy and practice without the requirement for additional skills, training expertise or resources for centre staff. Nevertheless, more translational design studies to replicate these results, including ongoing educator support and resources, in larger cluster randomized trials are required. Of note, trials that include multiple constructs of practices or policies, within an intervention, create difficulty to independently assess the effect of a single practice or policy.

To date, providing curricula that offer opportunities for developmentally-appropriate moderate-to-vigorous active play and fundamental movement skill development have moderate effects in promoting physical activity. It may be that such approaches are simply ineffective and that alternative strategies require exploration. Nonetheless, it should be noted that these studies: 1) focused on obesity prevention rather than physical activity, 2) provided activity sessions that were relatively brief in duration (~ 30 min) and low in frequency (three days per week); 3) were implemented over a relatively short time period (≤6 months); and 4) employed physical activity measurement protocols with limited sensitively to detect changes in physical activity behaviour.

Adult-led physical activity programs delivering highly structured exercise training sessions on a daily basis resulted in higher levels of physical activity. However, it is important to note that these studies were primarily exercise training studies in which physical activity was the factor being changed, not the outcome of the change. Thus, it is questionable whether these findings can be generalized to public health approaches to promoting physical activity in young children.

Implications for Parents, Services and Policy

For policy makers and service providers, the extant research literature provides limited guidance as to what approaches are effective in promoting physical activity in young children. The research suggests that training childcare staff to increase opportunities for physical activity in the classroom and during recess may be an effective strategy. The challenges being in intervention compliance, where increased fidelity may result in higher levels of physical activity when outcomes are assessed. Interventions requiring multiple health policies or practices in these settings may require additional or different types of implementation support. From a public health perspective, the focus on childcare provider training is particularly attractive, since the trainings could be mandated as a licensure requirement and delivered through existing childcare worker education and training networks.

Based on the evidence, policy makers and service providers should be wary of adopting stand-alone curricula offering structured physical activity and movement skill training, as there is mixed evidence to support their effectiveness. However, it should be noted that structured programs are not likely to do harm to young children; and in practice, such programs may offer substantial benefit to children when they are implemented in a responsible, developmentally-appropriate manner.

While the evidence related to physical activity interventions in child care settings is not definitive, it is well-established that parents play a significant role in shaping and supporting their children's physical activity behaviour.[2,13-17,38] In the constraints of evidence-based programs to promote physical activity in childcare settings, parents must be willing to take responsibility for encouraging and supporting their children's physical activity behaviour. The development of programs to educate and support parents in this endeavour should therefore be a priority.

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Physical Activity, Sedentary Behaviour and Sleep in Infants, Toddlers, and Preschoolers

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Introduction and Subject

It is estimated that in 2019 at least 38 million children under the age of five were overweight globally.[1] The pediatric obesity epidemic has heightened interest in physical activity (PA), sedentary behaviour (SB), and sleep during early childhood as correlates of energy balance and body composition. A sufficient amount of PA, low levels of SB and a sufficient amount of sleep are known to counteract overweight and obesity.[2,3,4,5,6,7,8] These behaviours can easily be shaped in children under five years of age, as they are most susceptible for changes in behavioural habits.[9] Therefore, early interventions targeting PA, SB, and sleep are important to prevent overweight and obesity.

More recently, PA, SB, and sleep have been investigated from a 24-hour perspective. This means that every activity that one conducts within a 24-hour time span can be categorized as either PA, SB, or sleep. These behaviours interact, which means that time spent on one of these behaviours has consequences for the time that can be spend on the others. In 2019, the World Health Organization published 24-hour movement behaviour guidelines for the early years (0-4 years old), which confirms the importance of this approach.[10] More specifically, the 24-hour movement behaviour guidelines state that:

- **Infants** (<1 year old) should:
  - Engage in 30 minutes of tummy time per day;
  - Avoid sedentary screen time and should not be restrained for more than one hour at a time;

    - Sleep between 14 and 17 hours per day until the age of 3 months, and between 12 and 16 hours per day until the age of 11 months, including naps.

- **Toddlers** (1-2 years old) should:
    - Engage in 180 minutes of PA at any intensity per day;
    - Not be restrained for more than one hour at a time
    - Avoid sedentary screen time for toddlers younger than 2 years, and limit sedentary screen time to 60 minutes per day for 2-year-old toddlers;
    - Sleep between 11 to 14 hours per day, including naps.

- **Preschoolers** (3-4 years old) should:
    - Engage in 180 minutes of PA per day, of which 60 minutes is spend in moderate to vigorous intensity;
    - Limit sedentary screen time to 60 minutes per day, and should not be restrained for more than one hour at a time
    - Sleep between 10 to 13 hours per night.

These guidelines are different for infants, toddlers, and preschoolers, since the age range of 0 to 4 years encompasses three developmental periods, each of which is characterized by different movement behaviour patterns.[11,12]

The infant period generally encompasses the first 12 months of life. Activity or movement in the first 6 months is restricted to reaching and grasping objects, turning of the head towards a stimulus, and movement of the arms and legs. The second 6 months is characterized by the learning of rudimentary movement skills. The developmental stage from 1 to 3 years of age is often described as the toddler period. Around 1 year of age, children commence walking. With this increased opportunity for exploration and learning, toddlers develop locomotor skills such as running, jumping, and hopping. Further, manipulative skills also emerge in the toddler years. The preschool period incorporates ages 3–5 and is characterized by further development of stability, locomotor and manipulative skills.

Next to differences in activity patterns between 3- to 5-year-olds and younger children, estimates of daily PA and SB in infants and toddlers are more likely to be influenced by daytime sleeping

patterns than in preschool children, as infants and toddlers spend more time taking naps during the day than preschoolers.*13*

Even though the evidence is limited, a few studies found associations between meeting the 24-hour movement behaviour guidelines and health indicators in infants, toddler, and preschoolers.[14] A review by Kuzik et al. suggests that specific combinations of sleep, PA and SB are associated with health indicators in 0- to 4-year-old children. For infants and toddlers, high sleep and low SB were favorably associated with adiposity. High PA and low SB were favorably associated with fitness and motor development in preschoolers, and for toddlers and preschoolers, the associations were inconclusive as some studies found a favorable association between high PA and low SB and adiposity, while others found none.[15] Rollo et al. examined the health benefits of meeting all three 24-hour movement guidelines in toddlers and preschoolers. The results of their review showed that preschoolers who met the integrated 24-hour guidelines displayed better social-cognitive development, better health-related quality of life, and fewer behavioural and emotional problems. Meeting the guidelines was not associated with adiposity in toddlers. However, the results were indecisive as to whether meeting the 24-hour guidelines had a beneficial impact on adiposity outcomes in preschoolers.[16]

Research Context

The literature was searched for studies evaluating the prevalence of compliance with the integrated 24-hour movement behaviour guidelines (i.e., PA, SB, and sleep) in healthy infants, toddlers, and preschoolers. While the interest in PA, SB, and sleep in isolation has increased over the past decade, studies on the integrated approach of looking at PA, SB and sleep in children under the age of five are scarce.

Research Results

Infants

At the moment, only two studies assessed compliance with the 24-hour movement behaviours in infants.[17,18] In both cross-sectional studies, sleep, SB and PA were proxy-reported using a parent questionnaire. Adherence to the guideline for SB was separately calculated for screen time and time being restrained. In the first study, Hesketh et al. included 455 Australian infants. In the second study, Hesketh & Janssen included 167 UK children from 0 to 18 months old, of which 109 were infants. In both studies, high compliance with sleep (58.7% - 76.2%) and restrained

(56.9% - 58.7%) guidelines, and low compliance with screen time (27.9% - 41.3%), tummy time (29.7% - 30%) and the combined 24-hour guidelines (3.5% - 4.6%) was found. Only for the Australian infants, a higher percentage of girls than boys met screen time (32.5% vs. 24.0%) and combined guidelines (5.7% vs. 1.6%).

Toddlers

Furthermore, only one longitudinal and three cross-sectional studies assessed toddlers' adherence to 24-hour movement behaviour guidelines.[19,20,21,22] The studies took place in the USA, Australia, Canada, and New-Zealand. All studies used parent questionnaires to assess screen time, and accelerometers to measure PA. To assess sleep, most studies used accelerometers, and one study used a parent questionnaire. Two out of three studies measured SB next to screen time, using an Actigraph GT3X+ or a parent questionnaire. In most studies high proportions of toddlers complied with PA and sleep guidelines, while low compliance was found for screen time (11.4% - 44.7%), and for the overall 24-hour movement guidelines (8.9% - 34.0%). A longitudinal study by Meredith Jones et al. found differences in adherence to the 24-hour guidelines between children of 1 and 2 years old. Compliance with PA and sleep guidelines increased, while compliance with screen time recommendations decreased, which resulted in an overall decline in 2-year-old toddlers meeting the combination of the 24-hour guidelines. Furthermore, two studies examined differences in compliance between sexes, of which one study concluded that a significantly higher proportion of one year old boys (46.2%) than girls (30.3%) met the individual PA guideline. Another study assessed the association between the home environment in infancy and compliance with the 24-hour guidelines at 2 years of age. Toddlers who met the screen time guideline lived in homes with more developmental stimulation, while toddlers who complied with the combined guidelines lived in homes with more organization. A greater abundance of toys was present in the homes of both groups.

Based on the few studies that have been conducted, it can be cautiously stated that there is an indication that predominantly high levels of screen time are already present in children under three years of age and that low adherence to the 24-hour guidelines is primarily due to excessive screen time.

Preschoolers

In contrast with research on 24-hour movement behaviours in infants and toddlers, several studies already investigated 24-hour movement behaviours in preschoolers.[22-45] These studies were conducted across the world and overall found low to very low compliance with the 24-hour movement behaviour guidelines, ranging from 2.0% in Brazil to 36.8% in New Zealand. In a review by Tapia-Serrano et al. no significant differences in overall compliance with the 24-hour guidelines was found between preschool boys and girls.[46] In some countries, the overall low compliance rates were attributed to low compliance with PA guidelines while in other countries, low compliance rates were attributed to low compliance with screen time guidelines. This shows that compliance to the isolated guidelines differs between countries. This could be due to country specific differences in culture, policies, regulations or legislations. Another reason could be the use of other measurement devices (e.g., ActiGraph accelerometers versus Actical accelerometers) and other processing decisions (e.g., accelerometer cut-points) to capture PA levels in this young age group. For example, in the study of De Craemer et al., accelerometer cut-points by Reilly et al. were used to distinguish between SB and total PA, while the studies of Chaput et al. and Cliff et al. used the accelerometer cut-points of Pate et al. and Evenson et al. respectively.[25,28,29,47,48,49] In addition, not all studies on compliance with 24-hour movement behaviour guidelines included 60 minutes of moderate to vigorous intensity PA within the guideline of 180 minutes of total PA per day, which might create a distorted image. The review by Tapia-Serrano et al. suggests that differences in compliance with the 24-hour guidelines between countries are related to the countries' scores on the Human Development Index (HDI), which measures the social and economic development of each country. Young people (3-18 years old) who live in countries with low social and economic development complied less with the three guidelines than those who lived in more developed countries.[46]

Research Gaps

Currently, research on 24-hour movement behaviour in this young age group is mainly cross-sectional. Therefore, more longitudinal and experimental study designs are needed to examine changes in compliance over time and to assess different health indicators across the lifespan. In addition, validated, reliable and objective measuring instruments to map the 24-hour movement behaviours are required. Most studies use subjective measures to assess sleep and screen time, and there is a limited validity and reliability for some of these questionnaires. Furthermore, there is too much heterogeneity in the measurement of sleep, PA, and screen time across studies, which makes it difficult to compare them. More harmonized, objective measures will help to

provide a more accurate image of the extent to which infants, toddlers and preschoolers around the world meet the 24-hour movement behaviour guidelines.[14,16,46]

Furthermore, to gain a comprehensive understanding of PA, SB and sleep during infant, toddler and preschool years, more research on 24-hour movement behaviours is needed in children under the age of three, and more research on the moderating effects of sex, age, ethnicity and socioeconomical status is needed for 0 to 5-year-olds. Due to the short, intermittent bursts of activities of young children,[12,50] only direct observation or objective measures, like accelerometers, should be used to define activity levels in infants and toddlers. However, we must be aware that there might not be a consensus on which accelerometer cut-points to use for infants and toddlers. This is comparable to the accelerometer issues in preschoolers, where there is also no consensus on which accelerometer cut-points to use.

In addition, using compositional data analysis is a next important step in analyzing 24-hour movement behaviours. Compositional data analysis is a technique to deal with multivariate data as portions of one finite whole, such as a 24-hour day. In other words, if we measure a total day, it is important to make the data relative (e.g., one 24-hour day represents 100%) which means that every behaviour represents a percentage or a relative amount of that total day. All percentages of all behaviours together is 100%. Relative data represent the amount of time spent on behaviour, which is only meaningful in comparison with the time spent in the other behaviours and not on its own.

Conclusions

While there is evidence that the combination of PA, SB, and sleep is important in the early years, it can be concluded that very little is known about these 24-hour movement behaviours in infants and toddlers. The limited evidence shows that very young children spend a large proportion of time using screens, which means that screen time is already common among infants and toddlers. In addition, low compliance rates to the 24-hour movement behaviour guidelines were found in preschoolers, which is mainly attributed to low proportions of time spend in PA and large proportions of time spend using screens.

Further research is advocated to improve understanding of basic aspects of 24-hour movement behaviours in infants, toddlers and preschoolers. Next to looking at guideline compliance, investigating 24-hour movement behaviour compositions should gain attention. Meanwhile,

efforts to promote PA, to minimize SB (e.g., media use), and to optimize sleep in infants, toddlers and preschoolers are advocated.

Implications for Parents, Services and Policy

If policies are to be designed and disseminated for the purpose of increasing PA, decreasing SB, and optimizing sleep among infants, toddlers, and preschoolers, those policies should be developed based on an improved understanding of basic aspects of 24-hour movement behaviours in these age groups. For example, parents know and understand 24-hour movement behaviour guidelines and are aware of tips and tricks to let their child comply with the guidelines.

Young children spend the larger part of their time at home, with their parents. Consequently, parents can have a strong influence on their child's health behaviour. Parents control the exposure to PA opportunities, act as role models and can use specific parenting practices, such as rules on television viewing or applying consistent bed routines.

Besides the home environment, the childcare environment may play an important role in achieving adequate PA levels, minimizing screen-time and achieving sufficient sleep during the day for young children since in many countries most children spend extensive time in childcare settings. Gubbels et al.[51] showed that childcare attendance at the age of 1 and 2 years was positively associated with body mass index (BMI) z-scores at 2 years, and a greater increase in BMI between these ages. Benjamin et al.[52] also found that infants who attended childcare in someone else's home during their first 6 months of life, had greater measures of adiposity at 1 and 3 years of age.

Moreover Gubbels et al.[51] showed in 2- and 3-year-olds that activity opportunities in the physical environment and prompts by staff and peers were related to more PA intensity in childcare, while group size was related to less PA intensity. These results indicate a need for additional exploration of PA practices in childcare and identification of opportunities for intervention. In general, it is important that all organizations involved in the development of infants, toddlers and preschoolers (doctors, daycare centers...) are sufficiently aware of the 24-hour movement behaviour guidelines and their benefits, so that they can advise and inform parents about these guidelines, which will contribute to the overall healthy development of young children.

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Physical Activity in Early Childhood: Topic Commentary

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Introduction

The six contributions which make up the topic of physical activity in early childhood provide an accessible and critical summary and synthesis of the recent research evidence in this area from subject specialists.[1-6] Their first contributions to this topic collection, just over a decade ago, reflected increasing awareness that physical activity influenced health and development in early childhood. They also reflected increasing concern over research studies from the early 2000's which found that levels of physical activity in young children were lower than had been expected.

A new paradigm emerged in the past five years of '24-hour movement behaviours' (time spent in physical activity; sedentary behaviours, notably screen time; sleep) in early childhood.[7] The 24-hour movement behaviour paradigm sees physical activity, sedentary behaviour, and sleep as interrelated: if time spent on one of the behaviours increases then time spent on the other behaviours inevitably decreases. For example, daily time spent in sedentary behaviour increases each year from around the time children go to school,[8] and this displaces time spent in physical activity.[9]

There is a common misconception that what matters about screen time is the *content* and not the total time spent in front of screens- leading to suggestions that parents, health professionals, and policymakers should be concerned only about screen *content* (e.g., violence). Reviews and syntheses of research evidence in the past decade, summarized in the topic collection,[1-3,6] show that the total amount of time spent in front of screens does matter to health and development in early childhood, both directly by increasing exposure to harmful content (e.g., food advertising), and indirectly by displacing time spent in physical activity and sleep, and by displacing more beneficial forms of sedentary behaviour (such as reading/interactions with family members). The *timing* of screen time also matters - for example screen time in the hour or so prior to bedtime is harmful to sleep in early childhood.[10]

Major landmarks in the field in the past decade which followed the paradigm shift include the first global guidelines for time spent in the 24-hour movement behaviours for the Under 5s in 2019,[11] and global strategies for preventing and controlling childhood obesity by limiting screen time/promoting healthy sleep routines/promoting physical activity in early childhood.[12]

Research and Conclusions

The first three papers in the collection[1-3] summarize the evidence which led to common national (so far in Canada, New Zealand, Australia, and South Africa) and global (WHO) guidelines on physical activity, sedentary behaviour, and sleep in early childhood. They also summarize the guidelines on time spent in each of the behaviours. While the authors note that there are gaps and limitations in the evidence, these guidelines have been developed using robust and well-established methods. Users of the guidelines -parents, health and education professionals, and policymakers- should therefore have confidence in them.

While the guidelines for time spent in the 24-hour movement behaviours are still relatively new, use of the guidelines has been patchy so far. One of the main uses of guidelines like these is in public health surveillance (monitoring of what percentage of the early childhood population actually meet the guidelines). Surveillance is a core public health activity-but physical activity surveillance is limited in most countries at present.[13] Surveillance is how national governments answer important public health questions: Is not meeting guidelines common? Are there inequalities in meeting the guidelines? What are the trends over time? What are the positive or negative effects of policy and the impacts of major societal disruptions such as the COVID-19 pandemic?

Reviews of the global evidence suggest that screen time increased substantially, and time spent in physical activity decreased substantially in young children since the onset of the COVID-19 pandemic.[14,15] The extent to which these behaviours will recover to the pre-pandemic normal (which in itself was undesirable for most young children) is unclear.

De Craemer and colleagues[6] show that, despite a number of gaps and limitations in the evidence, only a minority of infants, toddlers, and young children globally meet the combined physical activity/sedentary behaviour/sleep guidelines. This seems to be the case even where that might be unexpected (e.g., in low-and middle-income countries, and in rural settings).[6] Time spent in front of screens typically exceeds WHO guidelines greatly, globally, and probably from infancy

and toddlerhood into early childhood.[6]

Trost shows that simple and specific ‘off the shelf’ solutions to unhealthy levels of time spent in the movement behaviours are currently lacking.[5] However, the contributions by Trost[5] and by Hinkley and Salmon[3] provide hope that interventions to promote healthy levels of the 24-hour movement behaviours will be effective. Some ‘best bet interventions’ have been identified by research so far.[3,5] These include increasing time spent outdoors, parents facilitating active play and playing with their children, childcare /education centres offering both structured activity sessions and physically active unstructured play in outdoor spaces which are not too crowded, providing portable play equipment (which generally encourages higher activity levels than fixed play equipment) , greater use of stimulating outdoor environments with natural features, encouragement of active commuting to/from childcare centers.

Improving time spent in the 24-hour movement behaviours across the whole population of young children is also likely to need changes *beyond* the home environment and the childcare/education/healthcare environments. Cultural changes (to habits/norms), and more ‘upstream’ policy changes are likely to be required[13] for example, to restrict screen time, to change transportation and the built environment in ways which encourage physical activity and penalize physical inactivity. A rights-based approach might also be helpful. Active play is so important to child health and development that it has been enshrined in the UN Rights of the Child, and so greater emphasis on the right to play may drive policy changes which improve levels of the 24-hour movement behaviours in early childhood.[13]

Greater policymaker awareness of the ‘co-benefits’ of meeting the 24-hour movement guidelines in early childhood might also encourage policy change/more effective policy implementation: many high-income countries have favourable childhood physical activity policies but these are generally not well implemented or evaluated.[12] A higher prevalence of meeting the 24-hour movement behaviour guidelines in early childhood would have significant benefits beyond physical and mental health-for cognitive development and educational outcomes, public health COVID recovery, the climate crisis (e.g., by greater nature connectedness, by reduced dependence on motorized transport), the UN Sustainable Development Goals.[13]

Conclusion

In summary, the topic collection provides a critical summary of current scientific evidence on physical activity, sedentary behaviour and sleep in early childhood. Time spent in these behaviours in contemporary young children is usually inconsistent with optimal health and development. The topic collection provides a number of useful pointers to improving time spent in these behaviours in early childhood, and should be a valuable source of evidence-based guidance for families, health and education professionals and policymakers.

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