ENCYCLOPEDIA on Early Childhood Development

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

Marieke De Craemer, PhD, Vera Verbestel, PhD, Marga Decraene, PhD student, Sofie Naeyaert, PhD student, Greet Cardon, PhD

Department of Rehabilitation Sciences & Department of Movement and Sports Sciences, Ghent University, Belgium

November 2022, Éd. rév.

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.

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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]

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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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