A SCOPING REVIEW ON THE INFLUENCE OF SEASONALITY ON THE 24-HOUR MOVEMENT BEHAVIOUR OF CHILDREN

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Abstract

Movement guidelines are evidence-based recommendations which outline the amounts of physical activity, sedentary behaviour, and sleep required by children for optimal health. However, seasonality could influence how children meet the guidelines. Therefore, studies on the effect of seasonality on children's movement behaviours (i.e., physical activity, sedentary behaviour, and sleep) globally were explored via a scoping review approach. Methodological concerns such as integrative versus isolated focus on the movement behaviours and the assessment tools used were also explored.

The review followed the Joanna Briggs Institute (JBl) protocol for scoping reviews. Fourteen peer-reviewed studies from Australia, Europe, North America, and Japan on seasonality and movement behaviour in children were reviewed. Eight studies focused on physical activity, four focused on physical activity and sedentary behaviour or sleep, and two studies included all three movement behaviours.

All of the studies used accelerometers to assess movement behaviours except one pedometer study. Based on the literature in this area, children appeared to be more active during the summers in Europe and North America, and less active during winters. The case was reversed for Australia. With the evidence to suggest that seasonality influences movement behaviours in children, further research should be done to harness the positive influence and reduce the negative impacts of seasonality.

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Definition of Terms

Accelerometer- A device that can be used to assess movement behaviours in the form of level of acceleration in children (Troiano et al., 2014).

Children- Young people between the ages of 5 and 13 years (Tremblay et al., 2016).

JBI (Joanna Briggs Institute) protocol- The guideline for the conduct of scoping reviews. The JBI protocol is a checklist to ensure the inclusion of all relevant points in a scoping review (Peters et al., 2020).

Movement behaviour- Movement behaviour in children is described using its three major components, namely physical activity, sedentary behaviour, and sleep (Tremblay et al., 2016).

Movement guideline- Recommendations for optimal values (i.e., number of hours) for physical activity, sedentary behaviour, and sleep. While there are other movement guidelines globally, this scoping review uses the Canadian 24-hour Movement Guidelines as a template for the review. Movement guidelines and 24-hour Movement Guidelines are used interchangeably throughout this document (Tremblay et al., 2016).

Pedometer- A device that counts the number of steps taken as a form of physical activity assessment (Beighle et al., 2012).

Physical activity- The process of being physically active or engaging in activities that can increase the heart rate. Can be divided into light physical activity (activities that consume 1.5 to three metabolic equivalents) and moderate to vigorous physical activity which are activities that consume more than three metabolic equivalents (Tremblay et al., 2016).

PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews - an evidence-based reporting guide to ensure scoping reviews are reported with acceptable standards and format (Tricco et al., 2018).

Seasonality- Seasonality can be described as a routine change in significant, influential factors such as temperature, day-length, and humidity that are repetitive annually and can be used to describe the nature of the environment at specific timeframes of the year (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007).

Sedentary behaviour- Sedentary time can be defined as time spent with reduced energy expenditure of less than 1.5 metabolic equivalents which can be while sitting, reclining or in a lying posture (Thivel et al., 2018; Tremblay et al., 2017).

Scoping review- Scoping reviews map the literature on a particular topic and can help to identify research gaps, key concepts, and information that can be used to advance future research, practice, and policy. (Daudt et al., 2013; Pham et al., 2014).

Sleep- A state of restful partial subconsciousness with reduced sensory awareness and muscular relaxation that usually recurs nightly (Tremblay et al., 2016).

Chapter 1 Introduction and Background

Movement behaviour in children is described using its three major components, namely physical activity (PA), sedentary behaviour (SB), and sleep (Tremblay et al., 2016). Research on movement behaviour aims to guide children towards achieving and maintaining the recommended quantities of PA, SB and sleep on a daily basis (Tremblay et al., 2016). Until recently, individual studies, systematic reviews, and established guidelines have focused on individual movement behaviours in children (Carson & Spence, 2010; Tucker & Gilliland, 2007). With the realization that movement behaviours are interrelated, research is currently advancing towards examining the movement behaviours together rather than individually (Tremblay et al., 2016). Studying movement behaviours collectively within individual studies is consistent with the development of the Canadian 24-hour Movement Guidelines by the Canadian Society of Exercise Physiology (Tremblay et al., 2016). The integrative approach to movement behaviour research is reflected in other global initiatives such as the ParticipACTION Global Matrix 3.0 (Aubert et al., 2018) which is a comparison of children's activity across multiple countries to better understand PA and SB variations in children and youth worldwide.

Seasonality, defined as seasonal variations in a year, has been associated with an effect on movement behaviours among children and youth (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007). Specifically, PA, SB, and sleep, can fluctuate in response to seasonality. This scoping review aims to synthesize and gather evidence on the effect of seasonality on the movement behaviours of children.

An international perspective on the effect of seasonality on children's movement behaviour is important to allow the recognition of differences in movement patterns in children across the globe. The differences in seasonality across the globe might also explain movement behaviour variations and thus serve as points of consideration for stakeholders planning towards meeting healthy movement recommendations. Although the 24-hour Movement Guidelines originated in Canada, there are similar 24-hour movement guidelines in countries, such as Australia (Department of Health, Australia, 2019). Movement behaviour research should include the consideration of possible moderators, such as seasonality, which could influence children meeting the guidelines by encouraging or deterring children from engaging in movement behaviours (Hjorth et al., 2013). The weather and atmospheric conditions vary significantly according to time and place throughout the year, reflecting seasonal variations. These seasonal variations are considered to be a source of influence on children's movement behaviours (Hjorth et al., 2013), as explored by this scoping review.

The objective of this scoping review is to compliment and fill the gaps revealed from previous systematic reviews that have focused on seasonality and movement behaviours (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007). To clarify the current stance of the literature on how seasonality affects movement behaviour in children (i.e., 5 to 13 years old), this scoping review was conducted on related studies published after the Rich et al. (2012) systematic review to June 2020.

There are multiple points unaddressed from previous reviews (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007) conducted on the effect of seasonality on children’s movement behaviour, such as the non-inclusion of sleep as a movement behaviour, a more recent introduction of a consistent age description (5 to 13 years old) for children (Tremblay et al., 2016), and the publication of more literature on the topic. A scoping review is deemed ideal to discuss the current stance of the literature on the effect of seasonality on children’s movement behaviour due to the flexibility (i.e., ability to address a broad concept like seasonality) it affords in its conduct and also because it can help address variable gaps such as updates and changes in literature (Pham et al., 2014). Other forms of reviews (e.g., meta-analysis) do not afford the review of broader questions (Peters et al., 2020) and that is why they are not preferred to review the topic of seasonality on movement behaviour in children. A scoping review can also help determine the need for systematic reviews based on the available number and quality of studies revealed by the scoping review and the knowledge map provided (Peters et al., 2020; Pham et al., 2014).

The objective of this scoping review was to seek answers to the generated research questions on the effect of seasonality on children's movement behaviour when an age range of 5 to 13 years was specified for children. Additional aims included exploring whether movement behaviours were studied in isolation versus collectively (i.e., integrative focus), and describing the objective movement behaviour assessment methods used within each study. The overall aim was to update the literature on the effect of seasonality on children's movement behaviour.

Chapter 2 Literature Review

The 24-hour Movement Guidelines for Children and Youth

In 2016, the Canadian Society for Exercise Physiology (CSEP) published the first 24-hour Movement Guidelines for Children and Youth (Tremblay et al., 2016). The guidelines identify three main categories of movement behaviour (i.e., PA, sleep, and SB) and identify recommendations for each behaviour including their integrative contribution towards optimal health (Tremblay et al., 2016). It is noteworthy to mention that while Canada leads in the creation of the 24-hour Movement Guidelines, other countries have either adopted or created similar movement guidelines. An example is the creation of the Australian 24-Hour Movement Guidelines for children and young people (Department of Health, Australia, 2019), which has been adopted in New Zealand. The Australian guidelines are similar in their recommendation and can be used across the globe as they were developed from findings provided by numerous movement behaviour studies worldwide (Department of Health, Australia, 2019); however, the first movement guidelines from Canada (Tremblay et al., 2016) is used as a reference template in this scoping review. Because the movement guidelines are based on studies internationally, they can be used to assess movement behaviour studies across the globe and thus contribute to international growth of the literature.

The international acceptance of movement guidelines also builds towards global advancements in the field of movement behaviour studies as reflected in the Global Matrix 3.0 on PA (Active Healthy Kids Global Alliance, 2018) which includes 49 countries from all six continents. The main objective of the Global Matrix 3.0 is to showcase global PA and SB variations and correlates in children and youth across the globe (Aubert et al., 2018). The Global

Matrix 3.0 is a collection of PA and SB report cards from participating countries globally displaying the variation in activity among children internationally (Aubert et al., 2018). The report cards are used to assign a grade (e.g., "A" for highly active and "F" for lowest activity) to indicate PA or SB indexes in the countries (Aubert et al., 2018). The Global Matrix shows updates on levels of activity in children worldwide and currently shows that globally, a high proportion of children are not meeting the guidelines (Active Healthy Kids Global Alliance, 2018). Sleep reports were not included in the Global Matrix 3.0 (Aubert et al., 2018) but contributions from reviews that include all movement behaviours can help towards the construction of a prospective matrix on sleep in children worldwide.

The development of the 24-hour Movement Guidelines is also based on multiple reviews of studies on movement behaviour conducted globally (Tremblay et al., 2016). The movement guidelines were created based on findings from four systematic reviews (Tremblay et al., 2016). Carson et al.'s systematic review (2016) was conducted on 235 studies globally on healthy children and youth aged 5 to 17 years to assess the correlation between SB and health indicators such as fitness, behavioural conduct, and cardiometabolic condition. The authors deduced that increased recreational screen time such as watching television is associated with an increased risk of cardiometabolic disorders, behavioural misconduct, and lower fitness, while more time dedicated to homework and reading was correlated with academic growth (Carson et al., 2016).

The second systematic review, by Chaput et al. (2016), examined the relationship between sleep and health by reviewing 141 studies with 5 to 17-year-olds selected from 40 countries. Longer (adequate) sleep durations resulted in lower adiposity, improvement in academics, emotional stability, and well-being. Conversely, inadequate sleep was related to poorer physical and mental health (Chaput et al., 2016).

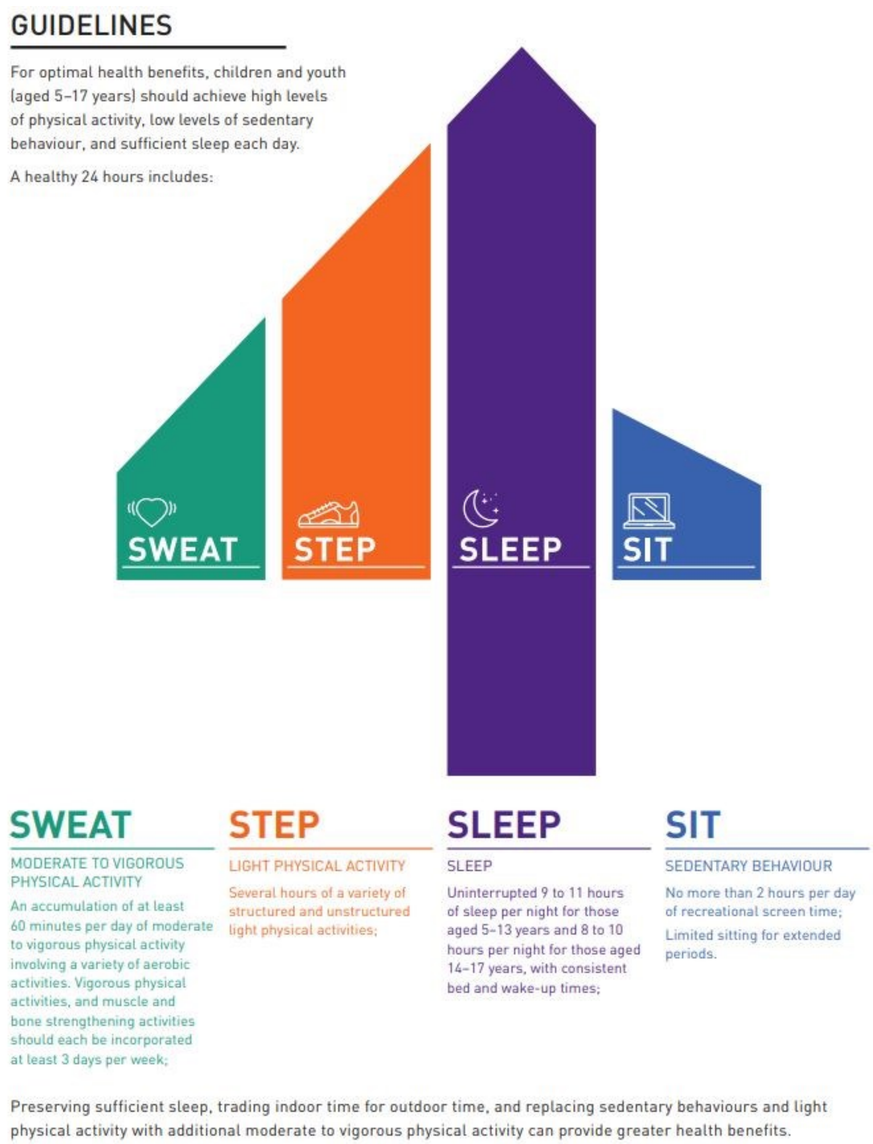
The third systematic review by Poitras et al. (2016) focused on PA in children between 5 to 17 years old and reviewed 162 studies published in different parts of the globe. The authors concluded that light PA and MVPA were directly and positively associated with physical, psychological, and mental health with more consistency in MVPA versus light PA (Poitras et al., 2016). The Poitras et al. (2016) study also noted that MVPA had a stronger correlation with physical, mental, and psychological health than light PA.

The last review combined the three movement behaviours (PA, sleep and SB) by including 13 cross-sectional studies from different parts of the globe and a prospective cohort study on 5 to 17-year-old children's movement behaviours (Saunders et al., 2016). Children that met all three guidelines had the best health indicators in terms of having low adiposity, reduced propensity to develop cardiometabolic disorders, or lower emotional instability (Saunders et al., 2016). The authors also reported that participants that met the guidelines for one or two of the movement behaviours had better health outcomes than those that met none of them, suggesting an interdependence between the movement behaviours and apportioned contribution towards health improvement (Saunders et al., 2016).

Finally, a compositional analysis was carried out to compare meeting the movement behaviours and resultant health outcomes (Carson et al., 2016). The results supported the findings in the systematic reviews (Carson et al., 2016; Chaput et al., 2016; Poitras et al., 2016; Saunders et al., 2016). Additionally, they revealed a correlation between meeting the 24-hour Movement Guidelines for all the movement behaviours and better health outcomes, emphasizing the need to study the movement behaviours in combination rather than in isolation (Carson et al., 2016). To allow for better simplification and interpretation, the movement guidelines have been described in simple terms such as sleep, sit, sweat, and step to describe the sleep duration, sedentary time, moderate to vigorous physical activity (MVPA), and light physical activity (LPA), respectively (Tremblay et al., 2016). The following paragraphs summarize the current Canadian recommendations for children's 24-hour movement behaviours and describe the associated research as depicted by Figure 1 below.

Figure 1

The Canadian 24-hour Movement Guidelines for Children and Youth



Note: Reproduced with permission from CSEP. Reference- https://csepguidelines.ca/wp-content/themes/csep2020/pdf/Canadian24HourMovementGuidelines2016_2.pdf

Sweat

The "sweat" category includes MVPA which consists of activities that consume above three metabolic equivalents (METs) and can be described in terms of daily physical activities (Thivel et al., 2018). MET is the unit for measuring physical activity, quantifiable as 1kcal/kg/hour (van der Ploeg & Hillsdon, 2017). The recommendation is one hour of MVPA (e.g., aerobic activities) per day including vigorous PA and muscles and bone strengthening activities should each be incorporated three days per week. According to the ParticipACTION Report Card (2020), only about 39% of children and youth meet the required guideline for MVPA per day in Canada. This MVPA inadequacy can contribute to predisposition to chronic diseases such as coronary heart diseases and diabetes (Saunders et al., 2016). It has been noted that 80% of 11 to 17-year-olds across the globe do not meet the MVPA criteria (Aubert et al., 2018). However, global surveillance data for PA is lacking among children specifically (Aubert et al., 2021).

Step

Numerous hours of LPA, both structured and unstructured, are also recommended in addition to the MVPA. The guideline's step component corresponds to physical activities that consume between 1.5 and 3 METs. LPA such as leisure walking is an important activity that helps in maintaining the locomotive functionality of the body and inadequacies in getting the recommended LPA time can also contribute to predisposition to chronic diseases (Saunders et al., 2016). While LPA is recommended as part of the 24-hour movement guidelines, there is no stipulated number of daily hours to mark benchmarks for meeting the required LPA (Tremblay et al., 2016). The Global Matrix 3.0 report shows that overall PA score was a D- (i.e., below A, B and C) indicating that less than 33% of children meet PA recommendations globally (Aubert et al., 2018)

Sleep

The "Sleep" guideline recommends nine to 11 hours of uninterrupted sleep for children 5 to 13 years old, and eight to 10 hours for youths 14 to 17 years old (Tremblay et al., 2016). The recommended nighttime sleep should also include consistent going-to-bed and wake-up times. Inadequate sleep has been linked to the prevalence of overweight and obesity in children in a study that measured sleep and adiposity using an objective method in 550 Canadian children with a mean age of 9.6 years (Chaput et al., 2011). Similar inadequate sleep duration effects were revealed by a meta-analysis of 45 studies globally with an age bracket of 2 to 102 years (Cappuccio et al., 2008). Despite these revelations on the deleterious effect of inadequate sleep, one in every four Canadian children still suffers from sleep inadequacy (Carson et al., 2016; Tremblay et al., 2016). Even though sleep has been noted as an essential component of the 24-hour Movement Guidelines (Tremblay et al., 2019), a meta-analysis of 65 studies selected from around the globe with an age range of 5 to 102 years has revealed that 16% of preschoolers, 20% of school-aged children, 30% of teenagers, and 32% of adults do not sleep optimally (Chaput et al., 2018). The ParticipACTION report (2020) noted that about 70% of Canadian children met the sleep guideline. Since sleep is vital for body functionality (Chaput et al., 2011), we should be concerned that about 30% of children are not getting adequate sleep (Chaput et al., 2018).

Sit

"Sit" refers to sedentary behaviour. The maximum recommended recreational screen time is two hours per day. Sitting for extended periods should be discouraged (Tremblay et al., 2016). However, there was no criterion identified for determining "extended hours" in the movement guidelines. Sedentary time can be defined as time spent in sedentary behaviour during wakeful hours that consumes less than 1.5 METs (Thivel et al., 2018). Sedentary time can be spent sitting, lying, or in a reclining position. For children, it can be subdivided into screen time (i.e., time spent watching television or playing computer games) and other non-discrete sedentary behaviours such as sitting to read or draw (Tremblay et al., 2016). The Global Matrix shows that children in 36 out of 39 participating countries did not meet the SB guidelines, scoring a D^+, meaning that less than 40% meet the SB guidelines (Aubert et al., 2018).

Factors Influencing Movement Behaviours in Children

McLeroy's ecological model describes child development as a relationship complex involving multi levels of influential factors (Özdemir, 2013). These factors are divided into direct influences such as family and schooling conditions to broader concepts including cultural practices, customs, and values (Özdemir, 2013). The model is divided into five systems, starting with the innermost microsystem consisting of a child's family, neighborhood, school, religious organization and health services (Özdemir, 2013). This is followed by the mesosystem which serves as the bridge between the microsystem and organizations in the exosytem such as social services, government organizations, extended family and mass media (Özdemir, 2013). The next outer level of influence is the macrosystem which comprises cultural attitudes and built ideologies (Özdemir, 2013). The last layer is the chronosystem involving environmental changes and thus serves as the position for seasonality as an influential factor on a child (Özdemir, 2013).

The socio-ecological model helps explain the different levels in which factors can affect children's behaviour (Ohri-Vachaspati et al., 2014). This includes individual (child) factors such as genetics and personal preference, personal family relationships, community, and the society (Ohri-Vachaspati et al., 2014). These factors can influence children's movement behaviour directly (e.g., parental influence on children behaviour) or through indirect connections such as school-based interventions reducing sedentary time and subsequently reducing weight accumulation in school children (Simon et al., 2014). As children continue to grow and adapt to their immediate environment, external factors such as family, neighbourhood, and seasonality may become more influential on their movement behaviours (Simon et al., 2014).

Seasonality is an example of an environmental factor that falls under the societal category of the socio-ecological model and can influence all the other levels of the model including individual, family and community (Lisovski et al., 2017; Ohri-Vachaspati et al., 2014; Özdemir, 2013; Simon et al., 2014). Seasonality can influence children at the individual level of the socio-ecological model by changing temperature and day-length which in turn can determine the mood of the child with regards to activity (Lisovski et al., 2017; Ohri-Vachaspati et al., 2014; Simon et al., 2014). Seasonal variations can also determine family plans (e.g., vacation plans), the type of sports organized at the community level (e.g., winter sports versus summer games) and societal norms, thereby affecting all levels of the socio-ecological model (Lisovski et al., 2017; Ohri-Vachaspati et al., 2014; Simon et al., 2014). Thus, seasonality despite being an external layer of the ecological model can also interact with lower levels of the model to impact children's movement behaviour.

Seasonality

Considering that seasonality can influence children's behaviour on all levels of the socio-ecological model (Simon et al., 2014), more research should be dedicated to revealing the influence of seasonality on children's movement behaviours and how it affects meeting movement recommendations. Seasonality studies are important since differences in ecology, weather components, and other seasonal correlates may significantly determine children's propensity to meet the guidelines (Kharlova et al., 2020). The global acceptance of movement guidelines, therefore, contributes to the need for a comprehensive review on seasonality and the movement behaviours in children.

Seasonality can be described as a routine change in influential factors such as temperature, light (day length), and humidity that are repetitive annually and can be used to describe the nature of the environment at specific timeframes of the year (Lisovski et al., 2017; Naumova, 2006). A season can thus be referred to as the state of the environment in a specific period within a year with specific attributable ecological and weather features (Alpert et al., 2004). The cyclical changes in seasonality elements that determine the transition from one season to the other are often based on meteorological findings on the sun's position and are mostly used to divide the year into four seasons (Xu et al., 2017).

Winter - It has been reported to start from around December 1st to February 28th. Winter is categorized as the season with the shortest day length and lowest temperature. Winter can be characterized by inclement weather such as snowfalls and freezing rain (Alpert et al., 2004; Xu et al., 2017).

Spring- It has been reported to be the period around March 1st to May 31st characterized by relatively moderate temperature and medium daylight (between the extremes of winter and summer). Most places might experience more frequent rainfalls during this season (Alpert et al., 2004; Xu et al., 2017).

Summer - It has been reported to be around the 1st of June to August 31st. Summer's features include a longer day-length compared to the other seasons and a higher temperature comparatively (Alpert et al., 2004; Xu et al., 2017).

Fall (Autumn) – It has been reported to be around September 1st to November 30th. It features a moderate temperature and daylight similar to spring but with leaves falling in most places (Alpert et al., 2004; Xu et al., 2017).

The descriptions above relate to the Northern hemisphere, while the dates are reversed in the southern hemisphere. Note that there are exceptions with this broad classification. For example, in parts of the world located near the equator, reduced variation in weather is experienced such that the weather can simply be classified into rainy and dry seasons, while parts of the globe farthest from the equator experience extreme features of the seasons (Alpert et al., 2004). In addition, some countries or states are warmer than their surrounding countries or states (e.g., In the USA, southern states such as Florida are warmer most of the year than northern states such as Michigan) within the same continent (Alpert et al., 2004).

Globally, children's movement behaviour is a concern. According to Roman-Viñas et al. (2016), only about 7% of children worldwide meet all the movement behaviour (PA, SB, and sleep) recommendations. Seasonal variations may influence behavioural patterns (Lisovski et al., 2017; Ohri-Vachaspati et al., 2014; Özdemir, 2013; Simon et al., 2014) and thus may impact the conclusions drawn from global surveillance data (e.g., the Global Matrix) if the season of data collection is variable across regions. Therefore, seasonality requires concurrent consideration. For example, while children might be encouraged to participate in outdoor activities, weather events such as snowfall in winter or a hazy summer might discourage children from being active. The seasonal variations may influence whether or not children will meet the 24-hour Movement Guidelines (Hjorth et al., 2013) by hindering outdoor activities due to precipitation levels or promoting outdoor activity with uneventful (i.e., no snow, rain, or wind) weather. Therefore, reviewing studies that discuss seasonal impacts on children's movement behaviour provides insight into the role of seasonality as an influential factor in children's movement behaviour.

Seasonality as an Influence on Children's 24-Hour Movement Behaviour

Children have been recognized as a vulnerable population to environmental change, such as seasonality (Kharlova et al., 2020). For instance, a study of 325 British children aged 8 to 11 years using accelerometry revealed that children accumulated more PA time during the longer days of summer than any other season (i.e., winter, spring, and autumn) of the year (Goodman et al., 2012). This could be related to the school year being aligned with seasonal changes (i.e., school vacation often occurs during summer). A literature review of 27 studies (on children and adults) on weather influence and PA participation revealed that children engaged in less PA during days with snow fall between December and March in North America and Europe compared to days without snowfall (Chan & Ryan, 2009). However, they achieved more PA during less eventful days with no snowfalls or rainfall in the year compared to days with snowfall (Chan & Ryan, 2009). An accelerometer-determined observational study discussed additional information because they focused on the effect of seasonal changes as part of an active living research initiative in the Prairie city of Saskatoon, Canada (Katapally et al., 2016). The study included 455 children within the age range of 10 to 14 years and revealed that children in warm-wet-calm weather accumulated significantly lower sedentary time compared to all other weather conditions (Katapally et al., 2016). Even during the cold-dry seasons, the children had a significantly higher sedentary time during the cold-dry-windy weather compared to those in cold-dry-calm and cold-dry-wet-weather (Katapally et al., 2016). Since the state of the weather and seasonal variations can occur differently across the world, it is expected that the effect of seasonality on movement behaviour will also vary. The variations in children's PA and SB in accordance with seasonality reflects seasonal influence that demands further research to reveal what it looks like in a global picture.

Seasonality also impacts children's sleep patterns. For example, a study on seasonal variations in relation to 12 to 14-year-old children's sleep and PA conducted using accelerometry revealed that sleep efficiency (time spent sleeping while in bed) was higher in spring compared to winter (Quante et al., 2017). The sleep efficiency difference means that the time spent being asleep is higher in spring compared to winter (Quante et al., 2017). However, the case is reversed when comparing summer to winter, suggesting that the children slept better in winter compared to summer and this was associated with higher temperature and longer day-length in summer and spring compared to winter (Quante et al., 2017). Overall, the difference in sleep efficiency as a movement behaviour situates seasonality as a notable influence on children's movement behaviour that is worth exploring.

Previous Reviews of Seasonality and 24-hour Movement Behaviours

Seasonality is an environmental factor that can impact children's movement behaviours, as shown in a series of review articles conducted between 2007 and 2012 (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007). The paragraphs below summarize the three systematic reviews (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007) conducted on seasonality and movement behaviour in children and youth. The strengths, gaps, and limitations of each review is also discussed accordingly.

A systematic review of 37 studies, only quantitative studies, from eight countries from Australia, Europe, North America and one study from Guatemala in Southern America, with no age restrictions, revealed that seasonality exerts a statistically significant effect on PA (Tucker & Gilliland, 2007). For example, seasons with extreme weather conditions like a cold winter or hot summer appeared to hinder the amount of PA that people achieved compared to warm spring and autumn (Tucker & Gilliland, 2007). About 73% (27 out of 33 studies) reported that seasonality significantly influences movement patterns in children and youth with reduced PA attributed to "bad weather" (e.g., extreme heat or cold). The researchers therefore, recommended indoor games as an option to increase PA (Tucker & Gilliland, 2007). Although the systematic review included multiple studies with diverse age ranges, increasing its generalizability, it focused primarily on PA and so does not provide a complete picture of the effect of seasonality on children's movement behaviours. Also, an age boundary was not set in this review (2007), reducing the clarity of the knowledge it provides on how seasonality affects movement behaviour in the children population specifically.

Building on the previous review (Tucker & Gilliland, 2007), Carson and Spence's (2010) review filled some of the gaps by focusing on an age range for children and youth (2-19 years). Studies included were published in English and provided results on more than one season (Carson & Spence, 2010). They reviewed 35 studies from Australia, Europe, North America, Portugal, and Senegal, and found that 83% (29 out of 35 studies) of the studies reported significant seasonal impacts such as reduced PA in extreme temperatures (e.g., freezing temperatures as reported by some of the studies) (Carson & Spence, 2010). It was reported that the impact of seasonality on children 3-6 years old was not significant across the studies reviewed (Carson & Spence, 2010). However, five out of six studies reported seasonal influences on PA in youth 12-19 years old (Carson & Spence, 2010). Of the 35 studies reviewed, 14 focused on 8-12-year-olds and reported seasonal impacts on seasonality such as reduced PA in winter compared to summer in Massachusetts, USA (Carson & Spence, 2010). The studies also noted that the impact of seasonality was most pronounced in 8-12-year-olds implying the need to focus intervention programs on children (Carson & Spence, 2010). However, an age range of 2-19 also allows the inclusion of early years (2-5 years old) youths 14 to 17 years old, and young adults 18 to 19 years old (Tremblay et al., 2016). In recognition of the effect of seasonality on children's movement behaviours, Carson and Spence (2010) recommended that there should be more awareness directed to parents, teachers, and community program coordinators about the effect of seasonality because children depend on them for activity scheduling. The Carson and Spence (2010) review also focused on only PA, like the Tucker and Gilliland (2007) review, thus providing a less specific perspective on children's movement behaviours in response to seasonality. They also included self-report studies alongside studies that assessed movement behaviour with direct methods which could affect comparisons of findings amongst the studies (Carson & Spence, 2010).

The most recent systematic review was based on 16 studies published up until June 2011 from Europe, USA, and New Zealand and researched the impact of seasonality on children's PA and SB (Rich et al., 2012). The inclusion of studies until 2011 allows for overlap of studies across the reviews, for example, the Baranowski et al. (1993) study was included within multiple reviews (Carson & Spence, 2010; Tucker & Gilliland, 2007) causing unnecessary repetition. The review defined a season as a section in a year characterized by specific changes in ecology, weather, and daylight hours (Rich et al., 2012), which is consistent with the definition or description provided by the previous reviews (Carson & Spence, 2010; Tucker & Gilliland, 2007). The study built on previous reviews by adding SB which includes inactive behaviours such as sitting at a desk. The rationale for including SB is that it is not simply the opposite of PA but plays an interdependent role in describing movement behaviour (Rich et al., 2012). SB is a required movement behaviour crucial for recuperation from PA exertion (Thivel et al., 2018) and transitioning into other movement behaviours such as sleep and PA, helping to complete the cycle of the process of movement (Thivel et al., 2018). The inclusion criteria of the review were that studies had to be published before and including June 2011, used objective methods to determine a minimum of one variable of PA or SB, compared for at least two seasons, and be conducted on children and youth between the ages of 2 and 18 years old in good health status (Rich et al., 2012). Their findings showed that there has been more research focused on PA than SB and that fewer studies were conducted on younger children 5 to 13 years old compared to adults (Rich et al., 2012). Inconsistencies in assessment techniques such as heterogenous accelerometer protocols and outcomes measures were also noted (Rich et al., 2012). Therefore, Rich et al. (2012) called for more studies on SB using objective methods and a more consistent assessment method. This implies that a more accommodating review style such as a scoping review (Moher et al., 2015) could further explain the role of seasonality in movement behaviour studies that contain heterogeneity in their choice of objective assessment devices. The devices used in assessment of movement behaviours is highlighted compared and discussed to see if the assessment tools are getting more consistent.

Similar to Carson and Spence (2010), Rich et al. (2012) included a wide age range that spanned the early years, childhood, and adolescence. The publication dates were between 2002 and 2010, with data collection between 1997 and 2007; thus, the studies were conducted before the establishment of any of the current 24-hour Movement Guidelines. The systematic review only reported findings from Europe (United Kingdom), the United States of America, and New Zealand, with no available studies from major geographic locations such as Asia, Africa, South America, and Australia (Rich et al., 2012). For Europe and the United States, the study reported an increased PA level in summer with a concurrent decreased SB, but the case is reversed in winter. Nonetheless, the review could not find conclusive evidence to describe the effect of seasonality on SB and has cited the need for more studies on PA and SB (Rich et al., 2012). An additional development since the Rich et al. (2012) review is that it did not include sleep, which is recognized as an essential component of movement behaviour (Tremblay et al., 2016). Because the Rich et al. (2012) review and all its predecessors on the effect of seasonality on children's movement behaviour did not include sleep and have used a broad age-range for children and youth, these gaps are addressed in this scoping review. Rich et al. (2012) also noted the difficulty in conducting a meta-analysis with the studies due to the lack of uniformity in style of seasonal reports and movement behaviour assessment, however, this scoping review will be able to discuss the selected studies individually and comparatively for better knowledge extraction.

Recent Studies on Seasonality and Movement Behaviour in Children

Studies published since Rich et al.'s (2012) review have elaborated on seasonal effects on children's movement behaviours. There are more recent publications on the effect of seasonality on children's movement behaviour, such as the Atkin et al. (2016) study on children's PA and SB and similar seasonality versus movement behaviour studies in Asia (Tanaka et al., 2016) not included in the previous reviews. With other examples of seasonality versus movement behaviour studies, a review of the publications after the last review (Rich et al., 2012) should provide the required update on this literature.

An important addition to the topic of the effect of seasonality on children's movement behaviours is the study of sleep among children. Because sleep was recognized as a movement behaviour in 2016 (Tremblay et al., 2016) and the previous systematic reviews did not include sleep, it has been under-researched as a movement behaviour in children compared to PA and

SB. However, using studies on young adults and adults as an example, a prospective study on 1388 Japanese community residents 15 to 89 years old who reported their sleep pattern via a questionnaire in winter, spring, summer, and fall revealed that sleep quality and duration could be influenced by seasonality (Suzuki et al., 2019). The participants recorded an average of 11.4 minutes more of sleep in winter compared to summer which, not statistically significant, a variation nonetheless (Suzuki et al., 2019).

Sleep variations were also noted in an earlier study which compared the sleep diaries (for January and August) of about 400 participants with variable age ranges selected evenly from Ghana (Africa), where there is reduced daylight seasonal variations, and Norway (Europe), where daylight variations across seasons are more pronounced (Friborg et al., 2011). The study reported that reduced daylight in winter correlated with a delayed rise and bedtimes and was more apparent in Europe (Friborg et al., 2011). The apparent variations in movement behaviours with seasonal changes suggests that seasonality might affect movement behaviours, and thus, a better and more current description of its impact on children adds knowledge to this concept.

While sleep as a movement behaviour is less studied among children 5-13 years old compared to PA and SB, research supports its importance for health outcomes (Chaput & Janssen, 2016; Hjorth et al., 2013; Saunders et al., 2014). A cross-sectional study on 24,896 children and adolescents aged 10 to 17 years old in Canada found that almost one-third of children do not get adequate sleep and has called for a public health focus on children's sleep (Chaput & Janssen, 2016). The importance of sleep is further emphasized by a systematic review that included 110 articles from 40 countries (not specified) globally that studied sleep in children between 5-17 years old and the associated health outcomes (Chaput et al., 2016). The study revealed that shorter/inadequate sleep predisposed children to physical and mental health disorders (Chaput et al., 2016). Learning about potential seasonal variations in sleep provides better comprehension of the effects of seasonality on movement patterns.

While seasonality appears to impact children's PA, SB, and sleep (Quante et al., 2017; Rich et al., 2012), no review to date has explored the impact of seasonality on all three together, probably, because sleep was not recognized as a movement behaviour at the time of their conduct. The previous reviews suggest that there was a detrimental decrease in PA in winter in comparison to summer, while SB appears to decrease during the summer and increase in winter (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007). Sleep has also been reported to show similar variations with SB, meaning children had less sleep during summer compared to winter (Quante et al., 2017). The sleep variations across seasons can be detrimental if such variations prevent children from meeting sleep recommendations.

The evidence underlying the development of the 24-hour movement recommendations supports that these behaviours should be explored in concert rather than in isolation (Carson et al., 2016). Additionally, the 24-hour movement guideline integrative study style shows how an inadequacy in any of the movement behaviours could affect the other movement behaviours and the movement pattern overall such as an increase in PA correlating with decreased SB in a particular season (Carson et al., 2016). Indeed, various studies of children's movement behaviours have included sleep along with PA and SB. For example, an accelerometry study including 730 Danish children (8 to 11 years old) assessed PA, SB, and sleep in relation to seasonality (Hjorth et al., 2013). They found that during the winter, the children's SB and sleep increased by 5% and 2%, respectively, while their MVPA was 23% lower compared to other seasons (Hjorth et al., 2013). Additionally, there have been more recent studies focused on seasonality in children's sleep and PA (Quante et al., 2017; Nagy et al., 2019), SB (Reddy

Katapally et al., 2016; Saunders et al., 2014; Atkin et al., 2016; Tanaka et al., 2016; Chang et al., 2020), and sleep (Hjorth et al., 2013). Furthermore, following Rich et al.'s (2012) publication, the rise in the use of accelerometry as the recommended objective measure of movement behaviours (Troiano et al, 2014) suggests that more recent studies should have employed it for their research providing less biased findings (Lynch et al., 2019).

Devices used to Assess Movement Behaviours

The most common devices used to assess movement behaviours are pedometers and accelerometers apart from other devices like sport-watches and fit-bracelets (Corder et al., 2007; Le Masurier & Tudor-Locke, 2003). A pedometer is mostly used to count footsteps taken by using sensors to sense body movement (Beighle et al., 2012). Pedometers provide an easy and less expensive measure of PA compared to accelerometers; however, it only counts steps and so cannot measure the intensity of PA (Le Masurier & Tudor-Locke, 2003). Although pedometers can be easily procured to assess PA, they cannot be used to assess SB or sleep, limiting its viability for assessing movement behaviours (Corder et al., 2007; Le Masurier & Tudor-Locke, 2003). A merit of pedometers however is that because pedometers are only designed to count steps, their batteries last longer and therefore, can help collect data over a more extended period compared to accelerometers (Corder et al., 2007; Le Masurier & Tudor-Locke, 2003).

While accelerometers have been described as the latest and more accurate device to measure movement behaviours compared to pedometers, they are also more expensive. They require detailed data processing to analyze the collected data. This is possible because modern-day accelerometers usually include various visuospatial assessment components that allow improved accuracy and, consequently, a higher price (Le Masurier & Tudor-Locke, 2003). An example of the visuospatial components built into accelerometers is a strain-gauge that allows it to determine the force of movement, therefore, determining the intensity of PA assessment (Le Masurier & Tudor-Locke, 2003). Accelerometers sometimes include light-sensors that can be used to assess sleep objectively (Le Masurier & Tudor-Locke, 2003).

Types of Accelerometers

Accelerometers can be classified into different types based on criteria such as wrist-worn or waist-fitted (Troiano et al., 2014). Although they have been considered as devices that provide the most accurate measure of body movement, there is an on-going conversation as to whether waist-fitted accelerometers provide a more accurate measure than wrist-worn accelerometers and vice-versa (Loprinzi & Smith, 2017). A waist-worn accelerometer can provide a better triaxial measure in the sense that, except the body moves from a point to the other, it would not record movement while a wrist-worn accelerometer might record the movement of arm swings on a fixated body (Loprinzi & Smith, 2017). Conversely, waist-worn accelerometers are usually less comfortable on the body while wrist-worn accelerometer can be easily worn and taken off (Loprinzi & Smith, 2017). A systematic review of 11 studies including 570 participants from Brazil, China, Spain, the United Kingdom, and the United States revealed that waist-worn accelerometers assessed PA and SB more accurately in children than wrist-worn accelerometers (Lynch et al., 2019). Sleep is also better assessed by waist-worn accelerometers compared to wrist-worn accelerometers (Hjorth et al., 2012). The Lynch et al. (2019) systematic review and Hjorth et al., (2012) study implies that waist-worn accelerometers should be preferred to wrist-worn accelerometers during PA, sleep, and SB assessment in children. Conversely, it has also been noted that children have better compliance with wrist-worn accelerometers compared to waist-worn accelerometers making the wrist a preferrable option for compliance (Fairclough et al., 2016).

Apart from wear-type, accelerometers can also be classified based on model/make such as the ActiGraph, ActivPAL™ and GENEActive (Troiano et al., 2014). While no reported comparison on GENEActive accelerometers has been found at this point, ActivPAL™ accelerometer has been reported to provide more accurate SB assessment than the ActiGraph GT3X+triaxial accelerometer but a less accurate PA measure compared to the ActiGraph GT3X+triaxial accelerometer in children (Ridgers et al., 2012). The difference between PA or SB assessment accuracy in both ActivPAL™ and ActiGraph accelerometers however has not been considered significant enough to discredit the use of either device in movement behaviour assessment in children (Ridgers et al., 2012). Devices used to assess movement behaviours was reported in this scoping including the type of device (e.g., accelerometer or pedometer) and model of device. Possible analysis and comparison were also caried out to reveal differences in the devices.

Approaches to Reviewing the Literature

Grant and Booth (2009) have identified up to 14 ways to review the literature on a topic ranging from a general overview, critical review, rapid review and literature review to systematic review, meta-analysis, and scoping review. The most popular in-depth reviews include systematic reviews and scoping reviews (Grant & Booth, 2009). A systematic review is a review on a specific research question that uses reproducible methods to select, analyze, and critically appraise data from relevant studies while a meta-analysis employs statistical analysis to combine the data available (Grant & Booth, 2009). The advantages of a systematic review are that they can be used for quality assessment, research evidence confirmation, and can provide a replicable systematic synthesis of literature on a particular topic (Grant & Booth, 2009). The limit for systematic reviews, however, is that they can only be used for a specific topics and not broad topics (Moher et al., 2015).

A scoping review can be described as a process aimed at providing an overview of the literature on a concept (Peterson et al., 2017). Unlike systematic reviews and meta-analyses, which focus on specific narrowed research questions, a scoping review is geared towards understanding broader concepts in a selected field (Moher et al., 2015). While systematic reviews are used to investigate conflicting results and confirm evidence in research, a scoping review explores the volume of studies and reports the up-to-date findings on a concept (Munn et al., 2018). Scoping reviews do not quantify effect sizes or investigate the quality of studies like systematic reviews but focus more on highlighting available evidence and examining the conduct of research on a given topic (Munn et al., 2018), which are the requirements to fill the gaps in this body of literature. A scoping can also help determine if there are sufficient studies to conduct a systematic review (Peters et al., 2020; Pham et al., 2014). Since it has been eight years since the last systematic review (Rich et al., 2012) was conducted on seasonality and movement behaviour in children, a scoping review can show the availability of studies for a potential systematic review on sleep and seasonality in children for example.

Although the previous reviews (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007) have demonstrated that seasonality impacts movement behaviour in children, this scoping review clarifies what that impact looks like currently and also reveals advancements and current research perspectives on the topic. A scoping review is important because it extends well beyond a literature review's borders by searching for available studies and knowledge mapping (i.e., describing the depth of knowledge) based on an agreed protocol (Peters et al., 2020). The protocol (Peters et al., 2020) employed in conducting a scoping review provides structure when reviewing the literature involved in the conduct of a scoping review. Therefore, it serves as part of the solution to the issue of individual studies on a topic (i.e., isolated research/research in "silos") by providing a knowledge map and research gaps on topics of interest. For example, a study conducted on 344 scoping reviews published between 1999 to 2010 revealed that these types of reviews are becoming a popular tool used to successfully describe the knowledge attained in different fields and note the gaps for future studies (Pham et al., 2014). Therefore, using the Pham et al. (2014) study as a template, this scoping review grow the body of literature on the effect of seasonality on children's movement behaviour. Since Rich et al. (2012) noted inconsistencies in assessment styles as a limitation to their study and no review has been published since the recognition of sleep as a movement behaviour in 2016 (Tremblay et al., 2011), a scoping review will showcase the availability of studies for a potential systematic review update.

The Case for a Scoping Review on Seasonality and Children's Movement Behaviours

A scoping review is employed in this case over a systematic review because it is better at providing updates, highlighting literature gaps, and explaining the current perspective on the effect of seasonality on children's movement behaviours (Munn et al., 2018). The 24-hour Movement Guidelines have discussed the importance of studying and promoting the three main determinants of movement behaviour (i.e., PA, sleep, and SB) in unison (Department of Health, Australia, 2019; Tremblay et al. 2016). Therefore, this scoping review discusses the number of studies that included all three movement behaviour types against those studied in isolation or partial combinations which is not easily done with a systematic review because of the highly specific nature of systematic reviews (Munn et al., 2018).

Some studies (Davis et al., 2014; Portmann et al., 2009) have used scoping reviews to show the effect of climate differences on sports and recreational activities, therefore further justifying the applicability of scoping reviews to examine seasonal influences on movement behaviour. However, previous reviews included an age ranges that extended from the early years to adulthood (e.g., Rich et al., 2012 included ages 2 to 18 years old) which reduces the focus on only children. This scoping review, therefore, addresses the gap in this body of literature by focusing on childhood (i.e., ages 5-13). Lastly, the applicability of a scoping review to broader topics makes it preferrable over other types of reviews for the effect of seasonality on children's movement behaviours. The primary objectives of a scoping review support the aims of this review, which is to synthesize knowledge on seasonality's impact on children's movement behaviours. Progress with a systematic review on this topic would have been suboptimal as systematic reviews do not afford a multi-level approach of recognizing the literature updates while presenting an integrative movement behaviour research style and examining the methodological evolution that is planned into this scoping review. Therefore, a scoping review is considered better suited for the advancement of research on seasonality and movement behaviour.

Research Purpose

The objective of this scoping review is to build upon and address the gaps revealed from previous systematic reviews (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007) that have focused on seasonality and movement behaviours. The review will address the gaps from previously conducted systematic reviews, specifically by including sleep as a movement behaviour, examining a consistent age-range for children (5-13 years old), and summarizing the findings from studies that used objective measures. The scoping review is based on the literature since the last review of seasonality and children's movement behaviour (i.e., Rich et al., 2012). The age boundary of 5-13 years is consistent with how childhood is defined in the 24-hour Movement Guidelines (Tremblay et al., 2019). This scoping review also includes sleep as a movement behaviour and considers the integration of movement behaviours, instead of focusing on behaviours independently, as reflected in the current conceptualization of these behaviours in the 24-hour movement guidelines (Chaput et al., 2017; Saunders et al., 2016).

Scoping Review Questions

The research questions for this scoping review are divided into primary and secondary questions.

This study's primary aim is to examine how research on seasonality and movement behaviour in children has evolved since the publication of the last review (Rich et al., 2012). This will be accomplished by 1) mapping the studies conducted with children aged 5-13 since 2012 that explore the effect of seasonality on objectively assessed PA, SB, and sleep behaviours; and 2) summarizing the effects of seasonality on the movement behaviours of children described within the studies. To achieve this primary aim, the following secondary questions were explored.

First, where were studies on seasonality and children's movement behaviours conducted globally? Second, what are the assessment methods employed in the conduct of the studies? The study of assessment methods employed relates to discussing the various equipment used in measuring movement behaviours (e.g., accelerometers and pedometers). Third, how many studies explored movement behaviours in isolation compared to those that were studied collectively? The identification of studies that include all movement behaviours versus isolated focus helps identify points where more research is needed to inform recommendations for future studies. Fourth, how do the seasonal changes in movement behaviours within the studies relate to the benchmarks provided by the 24-hour Movement Guidelines (Tremblay et al. 2016)? The movement guidelines were used as a reference point to identify whether the seasonal effects reported in studies are likely to affect the extent to which children meet versus do not meet PA, SB, and sleep guidelines.

Chapter 3 Methods

PRISMA Extension for Scoping Reviews (PRISMA-ScR)

This scoping review was conducted using the Joanna Briggs Institute (JBI) guidelines and reported following the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). The PRISMA-ScR guide comprises a checklist that follows published recommendations from the Enhancing the Quality and Transparency of Health Research (EQUATOR) Network (Tricco et al., 2018). The PRISMA-ScR guide is composed of an evidence-based 22-item Scoping Review Checklist (SRC) developed to critically assess article selection and conduct of scoping reviews, thereby ensuring the quality and viability of the findings from the review (Cooper et al., 2019). The PRISMA-ScR model checklist is designed to allow scoping reviews to optimally fulfill the purpose of the study by synthesizing the required knowledge on the topic of study and describing the scope of the literature on the topic (Tricco et al., 2018; see Appendix A for the PRISMA-ScR checklist). The same methodology has been applied in scoping reviews on similar topics such as neighbourhood and social influences on physical activity (Kepper et al., 2019; Love et al., 2017), and therefore, it provided similar guidance to the conduct of this scoping review by serving as checkpoints throughout the process. There was no conflict of interest in this scoping review. Appendix B provides details of the full declarations.

Inclusion Criteria

An ethics application was not required to conduct this scoping review (see appendix C for more information). However, to satisfy the objectives of the review, each study was examined using inclusion and exclusion criteria that ensure the study aims aligned with that of the scoping review. These are modified versions of the criteria used by the previous systematic reviews conducted on the effect of seasonality on children's movement behaviour (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007). The inclusion criteria were organized based on the Participant, Concept and Context (PCC) recommended by JBI (Peters et al., 2020) for this scoping review and includes:

Participants

1- Participants involved in each study must have been healthy children between the ages of 5 and 13 years. However, studies that included plus or minus a year from the age limits were not excluded to prevent the exclusion of vital studies with minor birthdate discrepancies. The age adjustments are considered because seasonality studies can span months and thus, children that met the age criteria at the beginning of a study might not meet the age criteria at the end of the study and vice-versa. In cases where studies included a wider age span, studies must have provided specific reports on children to be included in the scoping review. In cases where the reports were not specific to children, the studies were excluded.

Concept

2- The articles must have discussed seasonality in comparison to one or more of the movement behaviour variables (PA, SB, or sleep). Articles can focus on only one of the variables, a combination of any two of the variables, or all the movement pattern components.

3- Studies must have used objective measurement to assess movement. The objective specification ensures that the studies explore the movement patterns in such a way that the findings can be reported comparatively alongside other studies. The only exception to the objective requirement was articles on sleep as there was no traditional guideline for sleep as part of children's movement behaviour prior to 2016, and there were fewer studies on it. Therefore, the plan was to include all studies on sleep regardless of the type of measures employed for sleep assessment.

4- Studies had to compare more than one season (e.g., winter and spring but not only winter or only spring). The study collection included studies that compared subtle seasonal variations such as those experienced in parts of the world with smaller seasonal differences or comparison of more similar seasons (e.g., spring against autumn instead of summer versus winter).

Context

5- Articles had to be published between January 2012 and July 2020. The search was conducted during the month of July 2020. This review takes into consideration that the first guidelines for children's PA was created in 2002 (Janssen, 2007) and in 2010 (WHO, 2010), and the first guideline for children's SB was created in 2010 (Tremblay et al., 2011) altogether making up the traditional guidelines. The date selection of 2012 and above also ensures the inclusion of only articles published since Rich et al.'s (2012) review, thereby avoiding unnecessary repetition.

6- Studies had to be published in English. The only English criteria ensures that the quality of the review is not affected by language barriers.

7- Studies had to be published in a journal indexed within a recognized database. The specific platforms that were searched were PubMed, MEDLINE, EBSCOHost, and SPORTDiscus. These platforms, alongside the references of the articles selected, were also searched individually for a thorough search.

8- Studies had to include access to the full text. The full text requirement ensured that the complete essence of the studies was captured and correctly coded into the review. The full text requirement also prevented the inclusion of preliminary studies and partial literature that can provide incomplete information that leads to misinterpretations in the review.

Exclusion Criteria

1- Qualitative studies carried out with subjective methods such as self-reports. To address the secondary research question on type of devices used in movement behaviour assessment, only quantitative studies will have to be reviewed resultantly excluding qualitative studies.

2- Pre-registered published protocols that have not been completed and are excluded to prevent the incorporation of incomplete or partial information into the scoping review. However, studies in progress (i.e., longitudinal studies) that have already published results on parts of the study were considered if they had satisfied other inclusion criteria requirements.

3- Studies that were conducted on animals or conducted in similar perspectives (e.g., dog ownership and physical activity across seasons). Avoidance of studies on animal prevented the influence of effect-modifiers on the findings reported in the studies, which could have blurred or change the actual effect of seasonality on movement behaviour in children.

4- Studies conducted on a special population, such as studies conducted on children with a disability or chronic health condition. The health status of children might influence their movement pattern, thereby modifying the results of the studies, and so should be given special consideration.

5- Studies with declared unresolved conflict of interest (e.g., being funded by health supplement company that can encourage biases) that can jeopardize the integrity of the procedure employed or results produced. For that reason, such studies would have been excluded from the scoping review.

6- Studies that do not satisfy the ethical criteria required for its conduct. Although it is expected that most studies published on the PubMed, MEDLINE, EBSCOHost, and SPORTDiscus platform should have been approved by the required ethics board, a check was still conducted. Ethical considerations ensured that studies included in the review are approved and should not easily be disputed for ethical reasons that can harm the integrity of the study and be transferred to the review.

Procedure

The steps employed in the conduct and reporting of this scoping review were adopted from the Joanna Briggs Institute (JBI) guideline for scoping review (Peters et al., 2020) as evidence-based guidelines developed from the guideline suggested by Arksey and O'Malley (2005) and Levac et al. (2010). The Arksey and O'Malley (2005) framework for scoping review has identified five steps (i.e., identifying the research question, identifying relevant studies, selection, charting and collation or summarizing of data). Levac et al., (2010) revised the framework but made no changes to it apart from suggesting the inclusion of an optional consultation step. The JBI guideline contains the same recommendations suggested by Arksey and O'Malley (2005) and Levac et al. (2010) with the inclusion of an optional consultation step in the conduct of a scoping review (Peters et al., 2020). The JBI guideline is selected for this scoping review because it is the most up to date guideline.

The steps involved in the procedure adopted using the steps recommended by the JBI guideline for this study are thereby as follows (Peters et al., 2020):

1- Research Question- Creation of the research question involves identifying the research questions of this scoping review as itemized in the purpose of the study.

2- Article Identification- Articles for the review were selected from platforms that contributed the most to the literature review and were used by previous reviews which are PubMed, MEDLINE and SPORTDiscus using the following search terms: “Seasonality”, “24-hour movement pattern” OR “24-hour movement behaviour”, “Physical Activity”, “Sleep”, AND “Sedentary behaviour” OR “Sedentary time”. The search was repeated with the word “movement behaviour” broken down into “physical activity”, “sedentary behaviour” AND “sleep”. The synonyms used were, “weather variations” OR “seasonality”, “exercise” OR “physical activity” and “sedentary time” OR “sedentary behaviour”. The search was filtered for “human”, “children aged 5 to 14”, “English” and “publications after 2012”. Selection was made from studies that were searched with the help of assistance from the staff at the Harris Learning Library Nipissing University, Ontario. Canada. The librarian revealed the library portal and showed how to select search platforms (i.e., PubMed, MEDLINE and SPORTDiscus) but did not refine or discuss the search terms for this scoping review.

3- Article Selection- Articles were screened by the author of this scoping review using the inclusion and exclusion criteria. The reference list of the selected articles was searched for more studies that satisfied the scoping review criteria, and these articles were further screened using the same inclusion and exclusion criteria. Articles that were excluded at the final stage from the review were entered into a separate section on the coding template alongside the reasons for their exclusion.

4- Charting- The coding template was created based on the required information (e.g., location, seasonality description and methodology) for this scoping review. The factors that were coded include a description of what seasonality entailed in areas where studies were conducted, age range, movement behaviour studied (in isolation or a partial combination), and type of studies in terms of assessment methods, research design, research conducted in extreme temperatures, results, location, and some gender differences. The primary supervisor reviewed the coding file for competence and functionality. Reliability coding has been used to improve the consistency of scoping reviews (Pham et al., 2014; Tricco et al.; 2016, Williamson et al., 2020), so a second researcher from the North PA lab at Nipissing University coded five of the studies selected randomly from the collection and the coding was compared to ensure consistency. Reliability coding showed 80% agreement. The remaining 20% difference in perspective was resolved upon discussion leaving no disagreement for reliability and functionality so the remainder of the studies were coded by the author of this scoping review in the same format. Due to the consistency observed in terms of inter-rater reliability and replicability, no further alterations were made to the template. On completion of the coding, five studies were selected at random and coded again by the author to check for consistency since it is possible that coding gets better with practice. The repeat coding yielded a replica of the previous coding indicating consistency of the template. Since the coding was done by only the author of this scoping review and was consistent in the coding process, there was no need to repeat the coding for the studies. The selected articles were coded by entering the relevant information into an excel coding template created by the author of this scoping review.

5- Collation and Reporting- The PRISMA diagram was created to represent the selection stages that led to the number of studies reviewed. Summary tables were created to reflect the methods and results coded from each article in relation to the research questions. The summary tables helped to create an overall summary of the findings.

Analytics Presentation

The findings from this review were presented using descriptive summary tables and charts. Results were discussed, focusing on the primary purpose of the review, thereby reporting on the scope of the literature on the topic since the publication of the last review by Rich et al. (2012) and revealed paths for future studies.

Chapter 4 Results

The results are reported based on the research questions exploring the effect of seasonality on movement behaviours in children, assessment devices for movement behaviours and isolated versus integrative focus on the behaviours. However, the headings from the methods section (i.e., selection, charting, collation, analysis and summary) are repeated to unfold the results as each step of the method was carried out.

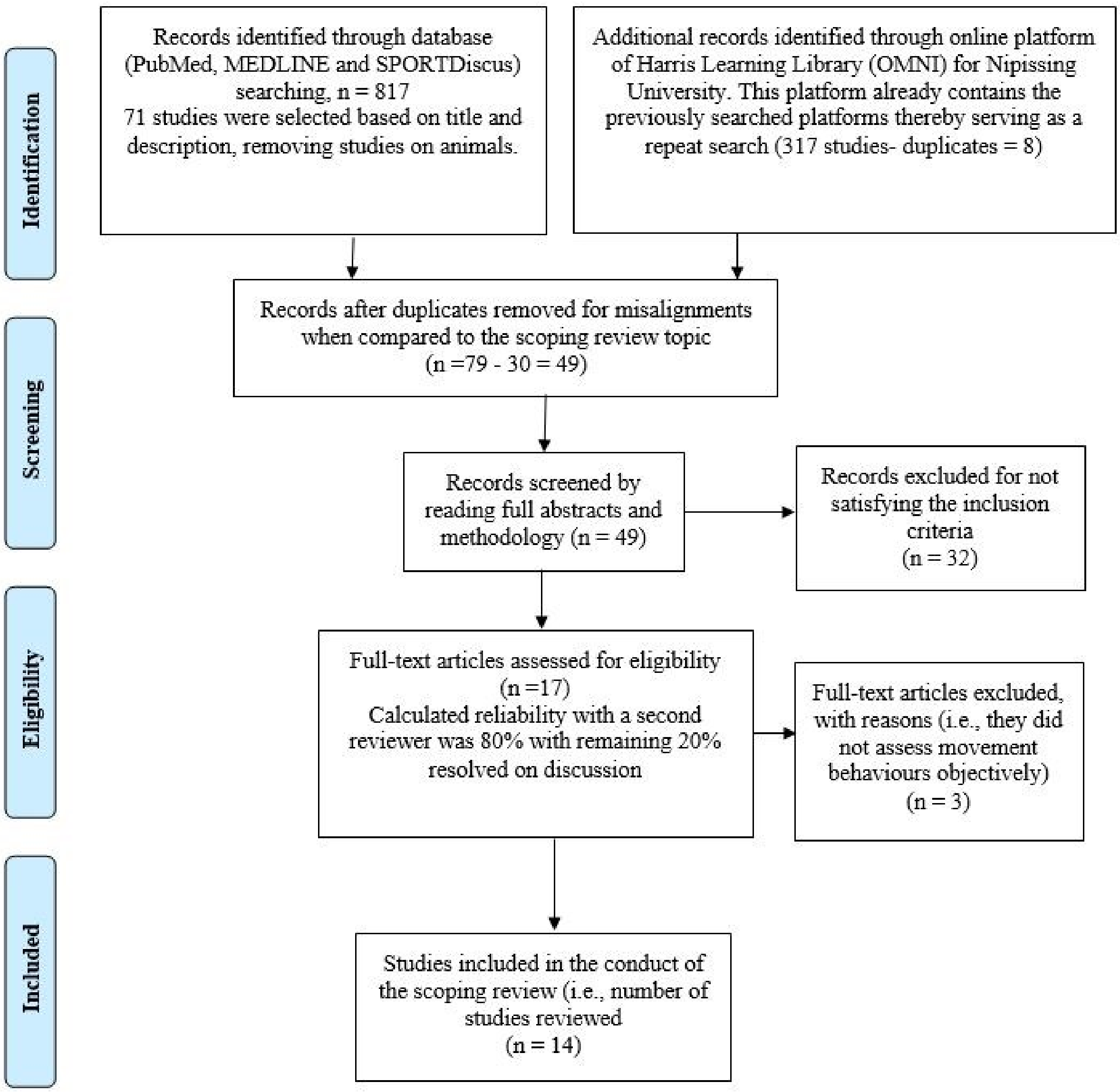
The Selection Process

Figure 2 is a PRISMA flow chart depicting the process involved in study collection for this scoping review. A search conducted on the selected platforms, PUBMED, MEDLINE, and SPORTDiscus yielded 817 studies, out of which 71 were selected by reading the study title and checking if the study description matched that of this scoping review. The search on the Harris Learning Library Platform (OMNI) for Nipissing University returned 317 articles, and after the duplicates were removed, eight articles were added to the 71 previously selected, adding up to 79.

The references of the selected articles were searched, but no new studies were revealed. On reading the studies' search terms, abstract and descriptions, 30 were excluded for being duplicated and for studying movement behaviours in a differing context to the topic of interest (e.g., seasonality in animals). Removal of the duplicates left 49 studies for analysis. Final analysis was carried out by reading the whole publication for the identified studies. Of the remaining articles, 22 were excluded for not satisfying the eligibility requirements such as age range and year of publication, leaving 17 articles. The studies were all coded; however, three more studies were excluded during the coding process, all due to the methodology employed (i.e., they used non-objective methods), which prevents direct comparison with the other studies.

Figure 2

PRISMA Flow Diagram for the Selection of Articles



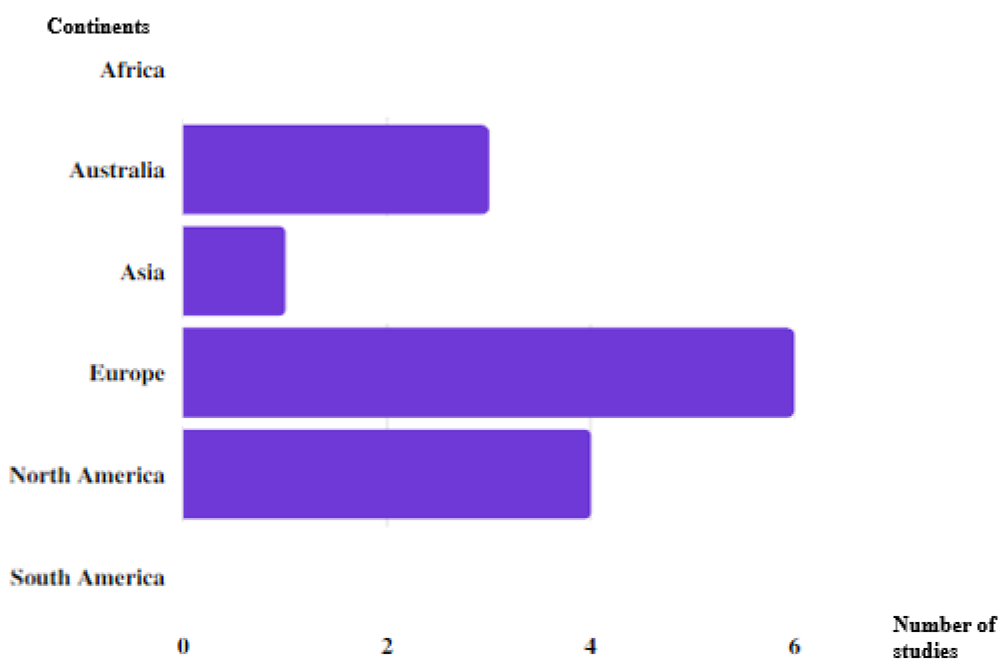
Adapted from Methodology for JBI Scoping Reviews (Peters et al., 2020).

Charting and Analysis of the Selected Studies

To address the aim of this scoping review, the included studies (*n*= 14) were first mapped in terms of where they were conducted globally and grouped by continent as seen in Figure 3. Then, the findings of these studies were summarized based on their geographical groupings.

Figure 3

Scoping Review Projection on the Globe



The vertical axis shows the continents around the globe while the horizontal axis shows the number of studies selected from each region.

From Figure 3, it is visible that this scoping review included studies from most continents around the globe. A different number of studies were available from each continent. For example, while Europe had as many as seven studies included, only three studies from Australia were included No studies that met the inclusion criteria were found from Africa and South America.

To better situate the analysis of the studies, they were classified based on their geographical locations (i.e., continents). The aim was to classifying studies in accordance with their description of seasonality. Therefore, it would have been possible to have some studies in North America classified into separate groups based on seasonality disparities across the continent (e.g., studies from warmer or colder parts of North America); however, differing seasonality reports from studies within the same continent were not noted. Therefore, there was no need for sub-classifications within continents.

Classification of Selected Studies

Europe

Six of the studies were conducted in Europe with three in the United Kingdom (Atkin et al., 2016 ; McCrorie et al., 2015; Nagy et al., 2019), one in Denmark (Hjorth et al., 2013), one in Norway (Deng et al., 2018) and one in Sweden (Pagels et al., 2016). The seasonality in the studies suggests that their autumn is from late August to November, winter is around November to February, spring is between March to the beginning of June, while summer starts from late June to early August of a given year. The studies focused on various age ranges in children between the ages of 6 and 12 using objective repeated measures.

Asia

This section contains a single study conducted in Japan (Tanaka et al., 2016). Although the authors did not provide an adequate description of seasonality for a full calendar year in this region, it was mentioned that summer was around July/August while the school terms ran for most of the other months (Tanaka et al., 2016). Children 8 to 9 years old were invited for the study, which was assessed objectively using repeated measures (Tanaka et al., 2016).

Australia

Three studies were conducted in Australia (Remmers et al., 2017; Ridgers et al., 2015; Ridgers et al., 2017). While the features might be similar for the seasons in the sense that winter has the lowest temperature compared to the other seasons, the calendar date for seasonality here in the southern hemisphere was reported differently from that in Europe, which is in the northern hemisphere. Winter occurred around the month of August to September, while spring was from October to November. Summer was experienced between February and March with autumn running between May and June of the year. The studies involved only school children between the ages of 8 and 11 years and used objective measures.

North America

Four studies (Beighle et al., 2012; Brazendale et al., 2018; Oreskovic et al., 2012 Quante et al., 2017) studies carried out in North America were included, and all were from the United States of America (USA). Two studies were from the southeastern United States with no specific states listed (Beighle et al., 2012; Brazendale et al., 2018) and the other two were from Massachusetts, in the northeastern United States (Oreskovic et al., 2012; Quante et al., 2017). All of the studies were carried out using objective methods as well using accelerometers and pedometers. The seasonality reported showed that spring occurred from the beginning of March to the end of May while summer begins in early June to August ending. autumn starts in September to November and winter was from December to February with the similarity in the description of seasonality noted by the four studies (Beighle et al., 2012; Brazendale et al., 2018; Oreskovic et al., 2012; Quante et al., 2017), no contrasting seasonal variations were noted, nullifying the need for within continent result comparisons. Additionally, one of the studies conducted in the southeastern United States (Beighle et al., 2012) only measured light physical activity using pedometers, which served more for comparisons in methods rather than seasonal contrast. The participants were aged 11-13 years, indicating a focus on school children.

Methods Employed in the Conduct of the Studies

One of the aims of this scoping review is to discuss the methods employed to assess movement behaviours in the included studies especially the devices used. Following Rich et al.'s (2012) recommendation for more seasonality and movement behaviour studies with consistent assessment tools, only studies with objective measures were included in the scoping review. A separate analysis was also carried out to compare the instruments employed in the assessment of movement behaviour in the various child populations involved in the studies. All the studies included in this scoping review used accelerometers to assess movement behaviour in children apart from one pedometer study on LPA from the USA (Beighle et al., 2012). All studies stated the brand of the accelerometer used; however, one of the studies (Pagels et al., 2016) did not state whether the accelerometer used was hip-mounted or wrist-worn.

A search on the accelerometer models listed revealed that eight of the studies reported that their accelerometers were hip-mounted (Atkin et al., 2016; Deng et al., 2018; Hjorth et al., 2013; Nagy et al., 2019; Oreskovic et al., 2012; Remmers et al., 2017; Ridgers et al., 2015; Ridgers et al., 2017) while three reported them as wrist-worn (Brazendale et al., 2018; Quante et al., 2017; Tanaka et al, 2016). McCrorie et al. (2015) noted that their accelerometer was thigh worn while one of the studies (Pagels et al., 2016) did not report the wear pattern of their accelerometer. Apart from the Beighle et al. (2012) MLS 2505 pedometer study, all of the other studies in this scoping review used accelerometers with 11 of them using the ActiGraph accelerometers (Atkin et al., 2016; Beighle et al., 2012; Brazendale et al., 2018; Deng & Fredriksen, 2018; Hjorth et al., 2013; Oreskovic et al., 2012; Pagels et al., 2016; Quante et al., 2017; Remmers et al., 2017; Ridgers et al., 2015; Ridgers et al., 2017). One study used the ActivPAL™ accelerometer (McCrorie et al., 2015) while another study used the Active style Pro JHA-350IT accelerometer (Tanaka et al., 2016).

Isolated versus Integrative Focus on Movement Behaviours

To further address the aims of the scoping review with regards to whether researchers used an isolated versus integrated focus on movement behaviours, the number of movement behaviours examined within each study was explored. Figure 4 shows the number and percentage of movement behaviours assessed by the studies reviewed.

Figure 4

Number and Percentages of the Three Movement Behaviours (n = 14) Studied

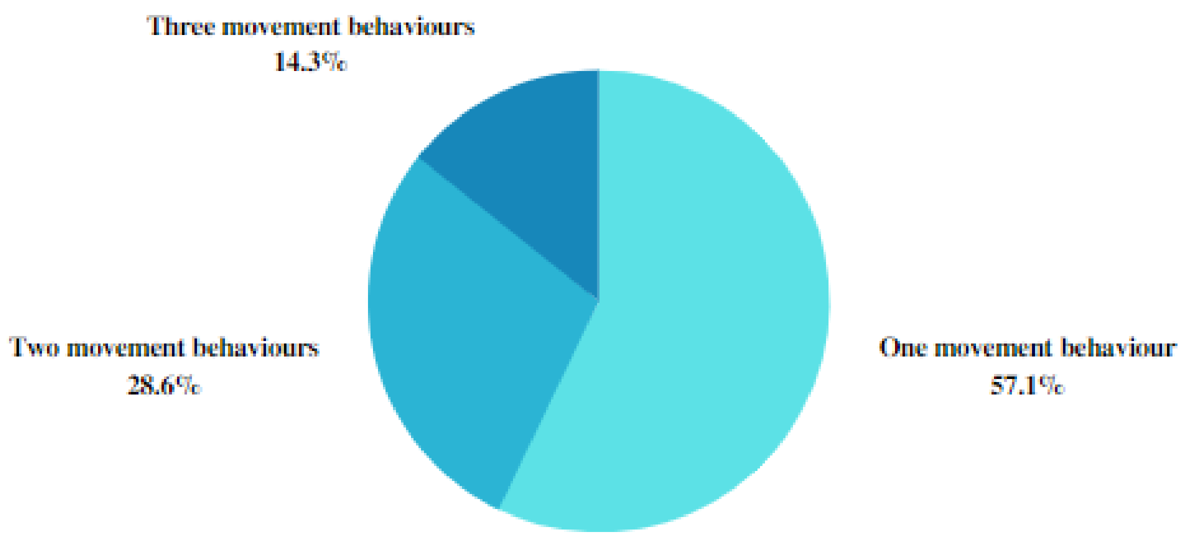


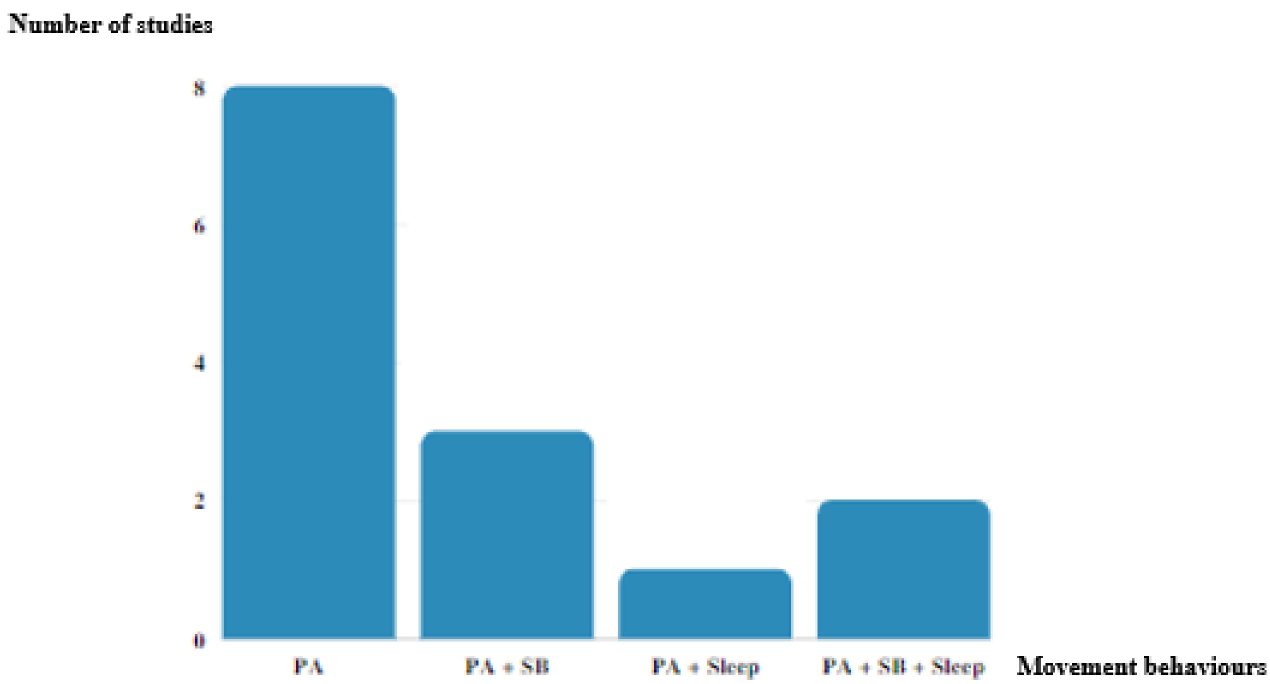
Figure 4 shows that out of the 14 studies included in this scoping review, eight studies focused solely on PA (Beighle et al., 2012; Deng & Fredriksen, 2018; McCrorie et al., 2015; Oreskovic et al., 2012; Pagels et al., 2016; Remmers et al., 2017; Ridgers et al., 2015; Ridgers et al., 2017). In contrast, four studies (Atkin et al., 2016; Nagy et al., 2019; Quante et al., 2017;

Tanaka et al., 2016), examined two movement behaviours (i.e., three on PA and SB and one on PA and sleep), and two studies included all three movement behaviours (Brazendale et al., 2018; Hjorth et al., 2013). There were no studies on the remaining possible movement behaviour combination (i.e., SB and sleep).

Figure 5 below shows the number of movement behaviours assessed by each study.

Figure 5.

Movement Behaviours Assessed by the Studies



The number of colour shades represent the number of movement behaviors included in each study and the particular movement behaviours included are also labelled below the horizontal axis.

As represented in Figure 5 above, out of the 14 studies included in the scoping review, all of the studies assessed PA in children. The unevenness of the bars also reflects that PA and SB were examined together most oftenof the movement behaviours. PA, SB and sleep had the second most combination while sleep and PA was only combined once and there was no sleep and SB combination. While it is worthy of appreciation that we have more studies on more than one movement behaviour, it is necessary to note that we still have a fewer number of studies that include all movement behaviours. Therefore, there is a limited view of how changes can affect the other assessment of movement behaviour in children. For a summary of the studies included in this scoping review alongside information related to the first research aim, Table 1 provides a concise list to present the information.

Table 1

Characteristics of the Studies (n = 14) Reviewed

Authors; Location	Seasons Compared	Movement Behaviour Assessments	Study Population	Seasonal Effect
Asia				
Tanaka et al., 2016; Japan	Spring (May to represent school year versus Summer (July/August)	PA and SB. Wrist-worn Active style Pro JHA-350IT. Seven consecutive days in each season	98 Japanese boys, M_{age} = 8.9 years (S.D = 1.8) and 111 girls, M_{age} = 9.1 years (S.D = 1.8) from 4 urban primary schools	Both genders: SB was higher in summer than spring ($p < .05$). Ambulatory and total LPA and MVPA, non-ambulatory LPA and step counts were lower in summer than in spring ($p < .001$). Girls: Non-ambulatory MVPA significantly lower in the summer than in spring ($p < .001$). The decrease in non-ambulatory MVPA in boys and increase in SB in girls were significantly lower in those who participated in sports compared to those who did not ($p < .040$ versus $p < .033$). Boys: The change in SB was significantly associated with having a television in the bedroom ($p < .022$)
Australia				
Remmers et al., 2017; Melbourne, AUS	All seasons, (i.e., winter versus spring versus summer versus autumn)	LPA, MPA VPA. Hip-mounted ActiGraph accelerometers. Seven consecutive days in each season	307 children (52% girls). For boys, M_{age} = 11.14 years (S.D = 0.67) and girls, M_{age} = 11.10 years (SD = 0.68)	Weather variation impacted MVPA, with temperature serving as the strongest predictor among the weather elements followed by solar radiation/daylight and humidity. During winter and spring in Melbourne, children engaged in significantly more MPA and VPA compared to summer and autumn ($p < .01$). There were no movement variations attributed to age or gender differences among the participants

Authors; Location	Seasons Compared	Movement Behaviour Assessments	Study Population	Seasonal Effect
Ridgers et al., 2015; Melbourne AUS	All seasons, (i.e., winter, spring, summer, autumn)	PA in the form of LPA and MVPA, and VPA. Hip-mounted ActiGraph accelerometers. Seven consecutive days in each season	326 primary school children, 8 to 11 years old. M_{age} = 10.0 (SD = 0.7). For girls, M_{age} = 7.4 (SD = 3.3) and boys, M_{age} = 10.4 (SD = 4.6)	Children achieved significantly less MPA and MVPA in summer compared to winter ($p < 0.05$). Compared to girls, boys engaged in significantly more MPA, VPA and MVPA, and had a higher frequency of MPA and VPA bouts and accumulated more time in these bouts (all $p < 0.01$). No significant differences reported for LPA and VPA
Ridgers et al., 2017; Melbourne Business District, AUS	All seasons, (i.e., winter versus spring versus summer versus autumn)	PA in the form of LPA and MVPA, and VPA. Hip-mounted ActiGraph accelerometers. Seven consecutive days in each season	326 pupils, 8 to 11-year-old. M_{age} = 10.4 (SD = 0.6 years); 119 boys, 127 girls	Children's MPA and VPA decreased between winter, spring, and summer, with a greater decline in vigorous PA. Decreases in lunchtime contribution to total vigorous PA and MVPA were noticeable in spring and summer. In comparison to the other seasons, lunchtime contribution to daily LPA increases in summer ($p < .05$)
Europe				
Atkin et al., 2016; UK (England, Wales, Scotland, & Northern Ireland)	Spring, summer, and winter	PA including MVPA, SB. Hip-mounted ActiGraph accelerometer. Seven consecutive days in each season	704 children, M_{age} = 7.6 years (SD = 0.3)	The children achieved a lower PA in autumn and winter relative to spring. Sedentary time was higher in autumn and winter compared with spring, and overall, there was more significant seasonal variation during the weekend compared to weekdays ($p < .05$)
Deng & Fredriksen, 2018; Horten municipality, Norway	Winter and summer	PA in the form of MVPA. Hip-mounted Actigraph accelerometers. Seven consecutive days, unless ill, showering, swimming, or absent from school	2123 children included in the study were aged 6 to 12 years. M_{age} = 9.20 years (SD = 1.75))	Seasonality was not the primary focus of this study, a decrease in MVPAs between winter and summer was also reported ($p < .0001$) with more activity in summer. This was a between group comparison across winter and summer

Authors; Location	Seasons Compared	Movement Behaviour Assessments	Study Population	Seasonal Effect
Hjorth et al., 2013; Denmark	Autumn, winter, and spring	PA, SB, sleep. Hip-mounted ActiGraph accelerometer. Seven consecutive days in each season	730 children of both gender between 8 to 11 years. M_{age} = 10.0 years (SD = 0.6)	Physical activity in the form of total PA and MVPA was lower in winter compared to other seasons; the case is reversed for SB while sleep was 2% longer during winter compared to spring ($p < .001$).
McCrorie et al., 2015; UK	Winter and summer	PA in the form of LPA. Mid-thigh mounted ActivPAL accelerometer. Eight consecutive days in each season	18 girls and 15 boys. M_{age} = 12.2 years (SD = 0.3)	Children took more steps in summer than winter. The difference in LPA was significant ($p < .044$) between 5 pm to 9 pm of the data collection days
Nagy et al., 2019; Bradford Area, UK	Summer and spring	LPA, MVPA and SB. Hip-mounted Actigraph accelerometer. Seven consecutive days in each season	492 White British (WB) and South Asian (SA) school-aged children between 6 to 8 years. M_{age} = 7.52 years (SD = 0.5)	Children were significantly more active in summer (MVPA, $p < .001$; LPA, $p < .001$) and spring (MVPA, $p = .005$; LPA, $p < .001$) compared to winter. They also engaged in less SB ($p < .001$) compared to winter
Pagels et al., 2016; Sweden	Fall, winter, and spring	PA in the form of LPA, MPA, VPA. Actigraph accelerometers. Five consecutive school days in each season (Wear type was not specified)	196 children (92 boys and 87 girls). Second grade (integrated age classes 7 to 10 years old, M_{age} = 8.7 years SD = 0.5), fifth (11 to 13 years old, M_{age} 11.7 years SD = 0.3), and eighth graders (14 to 15 years old, M_{age} = 14.7 years SD = 0.3)	Seasonality impacts the level of PA achieved by the children. They are least active during winter and most active during the months of May and September, (i.e., summer and fall) ($p < .001$)

Authors; Location	Seasons Compared	Movement Behaviour Assessments	Study Population	Seasonal Effect
North America				
Beighle et al., 2012; Southeastern USA	Fall and winter	PA in the form of LPA. MLS 2505 Pedometer. Four weekdays	112 participants were elementary school students from the southeastern United States between the ages of 8 and 9. M_{age} = 8.8 years (SD = 0.7)	While there were no significant differences in children's PA in school, seasonality affected children significantly out of school. The children accumulated 1153 more steps in the fall of October compared to the winter of February and was only significant ($p < .05$) outside of school
Brazendale et al., 2018; Southeastern USA	Summer and spring	PA in the form of LPA, MVPA, SB, Sleep. Wrist-worn ActiGraph accelerometer. Nine consecutive days during school and summer	30 participants. M_{age} = 8.2 years (SD = 1.2)	Comparing summer to school time (other seasons), children engaged more in sedentary behaviour, reduced light PA, accumulated a higher screen-time, got a longer sleep, and ate more sugar-based foods (6 days versus 2.5 days/week) including fruit (7 days versus 4.7 days/week) ($p < .05$)
Oreskovic et al., 2012; Massachusetts, USA	Winter, spring, and summer	PA in the form of LPA and MVPA Hip-mounted Actigraph accelerometer. Seven days (five weekdays and two weekend days)	24 mid-level school children aged 11 to 12 years. (M_{age} and SD were not provided)	Seasonality influenced PA, especially with the temperature component, as children tend to go outdoors more in warm weather. So, PA was higher in summer than winter and spring (level of significance was not reported)
Quante et al., 2017; Massachusetts, USA	All seasons (spring, summer, autumn, and winter)	PA, Sleep Wrist-worn Actigraph accelerometers. Seven to nine days	669 participants between 12 and 14 years M_{age} = 12.9 years (SD = 0.6)	The children slept faster when they went to bed in winter compared to summer ($p = .15$) but also achieved less PA in winter compared to summer and spring ($p < .05$)

Note: Seasonality is defined based on quarters of the year. LPA = light physical activity; MPA = moderate physical activity; VPA = vigorous physical activity; SB = sedentary behaviour. SD= Standard deviation, TV= Television, M_{age} = Mean age. Mean and *SD* are as recorded in the actual articles.

Summary of Seasonal Effects on the Movement Behaviours

All studies reported varying changes in movement patterns corresponding to seasonal variations. Starting with studies from Europe, Atkin et al. (2016) noted that children achieved significantly less PA in winter compared to spring and autumn but accumulated more SB in winter and autumn compared to spring. The Atkin et al. (2016) study was conducted on 706 children in the United Kingdom with an age average of 7.6 years. The Atkin et al. (2016) findings show that the children accumulated even more SB during the weekends compared to weekdays of the seasons studied and even less PA on weekends compared to the weekdays of any of the seasons.

A Norwegian longitudinal study on 2123 children aged 6 to 12 years old by Deng et al. (2018) also reported that children engaged in more MVPA in summer compared to winter, including a vital point that this variation increases as they grow into adolescence. The repeated measures study by Hjorth et al. (2013) was conducted in Denmark and included 730 children aged 8 to 11 years old, revealing that children accumulated five percent more sedentary time in winter compared to spring, summer and autumn but engaged 23% more in PA during summer compared to the remainder of the year (Hjorth et al., 2013). The children were also reported to have slept two percent more in winter compared to the other seasons. They also confirmed that the decreased PA in other seasons of the year except summer determined whether the children met the recommended movement behaviour guidelines overall (Hjorth et al., 2013).

The focus was placed on LPA by the McCrorie et al. (2015) study in the UK on 56 first-year students, mean age of 12.2 years, whose daily steps were assessed using repeated measures. The study additionally reported that children took more steps in summer compared to winter, with this difference in number of steps taken increasing between 5 pm and 9 pm daily. Also, in the UK, Nagy et al. (2019) conducted a similar study on 492 white British and South Asian children between 6 to 8 years and reported similar seasonal variations for PA measured in light, moderate and vigorous forms suggesting that seasonality affects PA in children regardless of the form of PA measured. Variation of daylight component of seasonality was further explored in another UK study (Pagel et al., 2016), where the amount of time spent outdoor was measured by a light sensor and correlated with a possible increase in PA. The authors reported that the 196 children, 7 to 14 years old, assessed spent more time outdoors during summer than winter, further agreeing that PA increases more in summer compared to winter (Pagel et al., 2016). It can as well be deduced that the increase in daylight during summer could be a contributing factor to the seasonal variation. All the studies from Europe reported that PA was highest in summer and lowest in winter and the three studies (Atkin et al., 2016; Hjorth et al., 2013; Nagy et al., 2019) that researched SB noted it was higher in winter compared to summer.

The only Asian study included in this scoping review is the Tanaka et al., (2016) study of PA and SB on 98 Japanese school children with an age average of about 9 years old. It was directed towards examining the seasonal variations of PA and SB during the summer of July/ August in comparison to May (i.e., spring) of the school year. They reported increased PA during the summer compared to spring and the reverse for SB. They also discussed that the nature of school activity during the school year and having television in the rooms could have contributed to the changes involved.

Remmers et al. (2017) is one of the studies from the Australian group that showed not just the difference in seasonality but the difference in its impact on PA. Although the concept of seasonality is discussed in terms of weather variation, the results still show seasonal influence in

PA in the 307 children with average age of 11.14 years (Remmers et al., 2017). In contrast to the reports from Europe, children in this study were most active during winter and spring compared to autumn and summer, with the highest MVPA in winter (Remmers et al., 2017). The authors further discussed the important weather elements that could have led to the MVPA variation and named temperature, daylight, and humidity as possible major influential factors (Remmers et al., 2017). Similar findings were again reported in the Ridgers et al. (2015) publication on seasonality effects on PA in 326 primary school children, which showed that the children were significantly more active in winter compared to summer. Two years later, in 2017, another publication on a similar seasonality topic but with a focus on lunchtime and recess among 246 children revealed that the case could be reversed at school but with same result for seasonal corelates shown in the other Australian studies (Ridgers et al., 2017). The Ridgers et al. (2017) study noted that during lunch specifically, children engaged in less PA and MVPA in spring and summer compared winter. This is the only study that looked into seasonal variations in activity during lunch time and thus reports different results compared to other European studies indicating that lunchtime can significantly change how seasonal influence is perceived (Ridgers et al., 2017). All the Australian studies reported similar results in terms of seasonality and movement behaviour variations.

In North America, similar results were reported which is not surprising as all of the studies that qualified for the scoping review happened to be conducted around the same region around southeastern and northeastern USA. Beighle et al. (2012) reported on seasonal variation in LPA studied using a pedometer in 112 elementary school children aged 8-9 years old. They reported that the children took more steps in autumn than in winter, signifying more activity in autumn compared to winter (Beighle et al., 2012). However, they added a note that this was not statistically significant within the premises of the school (*p* = .93) but statistically significant outside school (*p* = .043; Beighle et al., 2012). Twenty-four mid-level school children, 11 to 12 years old, were studied by Oreskovic et al., (2012) to determine the seasonal variation in their PA in the form of not just LPA but also MVPA. They also reportedly found that the children were more active during summer compared to winter (Oreskovic et al., 2012). The suggested reason for the increased activity during summer was that the weather was warmer during summer, and so they inferred that it must be one of the most influential seasonality variables (Oreskovic et al., 2012). Brazendale et al. (2018) conducted a study using accelerometers, where 30 African American children, average age 8.2 years, participated in the southeastern USA. They found that children achieved less PA in summer compared to May (spring) of the school year while they accumulated more sedentary time during the same period (Brazendale et al., 2018).

Lastly, Quante et al., (2017) was the only study included in this scoping review that focuses solely on sleep and PA in 12 to 14-year-old children (*n* = 669). It was conducted using objective measures and revealed that sleep also varies with seasonality (Quante et al., 2017). Quante et al. (2017) reported that sleep onset was six minutes lower in spring compared to the other seasons in a year, but the sleep duration was six minutes more in winter compared to summer although they were not statistically significant (*p* = .15) (Quante et al., 2017). Although no significance was noted, sleep was more efficient in spring compared to winter as the children slept 28 minutes earlier when they went to bed during spring versus winter, but the children got 41 minutes more sleep during winter compared to summer (Quante et al., 2017). The PA variations were in same direction with the other studies from the same region discussed earlier (Beighle et al., 2012; Quante et al., 2017; Oreskovic et al., 2012) except Brazendale et al., (2018) study which reported a lesser PA in summer compared to the seasons (spring) of the school year.

The spring versus summer comparison, different from the popular winter versus summer comparison in the other studies could be the reason for this different report.

In summary, all of the studies selected and reviewed in this scoping review reported the effect of seasonal variations on the movement behaviour of children assessed. The authors of all of the studies found seasonal variation in the movement behaviours they assessed. Out of the few studies that conducted analysis based on sex, only a few reported significant differences in the influence of seasonality due to age or sex of the children. The findings were similar in Asia, Europe, and North America, but opposite in Australia.

Comparative Summary

A general overview of the included studies for this scoping review shows that although similar terms are used to describe the seasons across different countries and continents, the weather connotations in such seasons can be very different. A good example is winter in Australia compared to winter in Europe or North America. Although the winter season still refers to the season with the lowest temperature, there is a remarkable difference in the extent to which the temperature fall, with values going well below zero degrees Celsius in Europe (Atkin et al., 2016, Deng et al., 2018; Hjorth et al., 2013; Nagy et al., 2019; McCrorie et al., 2015; Nagy et al., 2019; Pagels et al., 2016) and parts of North America (Beighle et al., 2012; Brazendale et al., 2018; Quante et al., 2017; Oreskovic et al., 2012). Conversely, the value stays above zero degrees Celsius for Australia (Remmers et al., 2017; Ridgers et al., 2017; Ridgers et al., 2015) and warmer parts of North America.

Seasonal Variations in the Context of 24-Hour Movement Guidelines

This scoping review's second main aim was to reveal the effect of seasonality on children's 24-hour movement behaviour at this current time. To answer this aim, the averages of each movement behaviour (MVPA, SB, sleep) reported within each season of the studies was compared to the recommended level of each movement behaviour (i.e., PA, SB, sleep) as per the 24-hour movement guidelines (Tremblay et al., 2016) to identify whether seasonal effects are likely to affect the extent to which children meet versus do not meet PA, SB, and sleep guidelines. In addition, it was noted whether the study explicitly compared their findings to an established movement behaviour guideline or a 24-hour movement guideline. Table 2 below describes the seasonal variations in the movement behaviours assessed, and the findings revealed. The seasonal correlates to movement behaviours are further compared with how it affects meeting the movement recommendations. Table 2 also contributes to the primary aim of the study (i.e., the effect of seasonality on movement behaviour in children) by exploring how seasonal differences in movement behaviours may relate to current recommendations. Results show that only one study (Hjorth et al., 2013) compared their findings to a movement guideline which are the traditional guidelines for SB and PA (Tremblay et al., 2011; WHO, 2010). Overall, the average movement behaviour durations within the studies did not meet the current Canadian 24-hour movement guidelines for PA, SB, and sleep even when positively influenced by seasonality.

Regarding whether the impact of seasonality is strong enough to determine if children meet the recommended movement guidelines, the study from Denmark (Hjorth et al., 2013) confirmed that seasonality could influence children towards or way from meeting the recommended one-hour MVPA daily (WHO, 2010) or not. In some of the studies reviewed, the mean values for the children fluctuated from meeting to not meeting the guidelines across seasons (Ridgers et al. 2015). For example, while the averages did not meet the PA recommendations in all the studies, in other cases (e.g., sleep) they met guidelines across seasons

(Remmers et al., 2017) The fluctuation suggests that the time of year when data is collected can influence surveillance reporting.

The result of the comparison as seen on Table 2 below shows that seasonal variations can contribute to the likeliness of a child to meet the movement recommendation in a particular season or not.

Table 2

Seasonal Variations in Movement Behaviours in relation to the Canadian 24-hour Movement Guidelines.

Authors	MVPA by Season	SB by Season	Sleep by Season	Comparison of Group Means with 24-Hour Movement Guidelines		
				MVPA	**SB**	**Sleep**
Asia Tanaka et al., 2016	LPA - min/day (SD) Boys, 107.5 (20.4) in May (Spring), 91.4 (27.5) in summer. *p* < .001 Girls, 104.1 (17.4) in May (Spring), 88.6 (23.0) in summer. *p* < .001 MVPA (min/day) Boys, 46.5 (15.0) in May.35.5 (19.8) in summer. Girls, 33.0 (9.9) May, 25.4 (11.4) in summer. *p* < .001	Boys = 340.6 (69.4) in May, 354.0 (73.8) in summer. Girls = 356.5 (60.6) in May, 370.6 (71.5) in summer. *p* = .015	Not Assessed	Not met in any season. Summer lower than spring.	Screen time was not reported so it is not comparable with the 24-hour Movement Guideline.	NA

Authors	MVPA by Season	SB by Season	Sleep by Season	Comparison of Group Means with 24-Hour Movement Guidelines		
				MVPA	SB	Sleep
Australia Remmers et al., 2017	LPA (daily minutes) mean (SD) 253.2 (70.8) in summer, 249.5 (71.9) in autumn, 258.2 (66.4) in winter, and 267.7 (73.1) in spring. $p < .01$ MPA (daily minutes), mean (SD) 43.7 (21.0) in summer, 45.9 (22.2) in autumn, 50.8 (20.6) in winter, and 51.8 (22.3) in spring. $p < .01$ VPA (daily minutes), mean (SD) 16.7 (14.4) in summer, 19.5 (15.2) in autumn, 25.1 (18.4) in winter, 21.4 (16.0) in spring. $p < .01$	Sedentary time min/day (SD) 467.1 (174.6) in summer, 492.2 (191.8) in autumn, 492.8 (181.3) in winter and 473.8 (176.1) in spring. $p < .01$	Not assessed	Using MPA + VPA = MVPA Children met the criteria in all the seasons. Autumn and summer were lower than winter and spring.	Screen time was not reported so it is not comparable with the 24-hour Movement Guideline.	NA
Ridgers et al., 2015	Winter; mean (SD) MPA 50.6 (13.4) VPA 25.1 (13.3) MVPA 75.8 (24.5). Statistically significantly lower MPA (−5.0 min) and MVPA (−7.8 min) in summer. Girls engaged in less MVPA in spring (−18 min) and summer (−9.2 min) and more MVPA in autumn (9.9 min) compared to winter	Not assessed	Not assessed	Children met the guidelines for MVPA in winter. Autumn and summer were lower than winter and spring.	NA	NA
Ridgers et al., 2017	LPA (min/day) 257.3 (43.9) in winter, 268.7 (52.1) in spring, 254.1 (47.9) in summer, and 250.6 (46.2) in autumn.	Not assessed	Not assessed	Using MPA + VPA = MVPA. Children met the criteria in all the seasons.	NA	NA

Authors	MVPA by Season	SB by Season	Sleep by Season	Comparison of Group Means with 24-Hour Movement Guidelines		
				MVPA	**SB**	**Sleep**
	MPA (min/day) 52.2 (13.4) in winter, 53.9 (15.2) in spring, 45.9 (14.3) in summer, and 48.9 (14.1) in autumn. VPA (min/day) 26.2 (13.4) in winter, 22.8 (12.4) in spring, 17.7 (10.3) in summer, and 21.0 (11.1) in autumn. MVPA (min/day) 78.5 (24.5) in winter, 76.8 (25.5) in spring, 63.6 (22.9) in summer, and 69.9 (23.0) in autumn.			Autumn and summer were lower than winter and spring.		
Europe Atkin et al., 2016	MVPA assessed in the study was 15% to 30% reduced in autumn and winter compared to spring.	SB was 55 minutes higher in autumn and Winter in comparison to spring.	Not assessed	Results are not comparable to the 24-hour movement guideline because of differences in units of measurement.	NA	NA
Deng & Fredriksen, 2018	Schools 1 to 4, assessed during the winter of January to March, achieved significantly 20 minutes less PA than schools 5 to 9, assessed from the summer of April to September 2015.	Not assessed	Not assessed	Results are not comparable to the 24-hour movement guideline because of differences in units of measurement.	NA	NA
Hjorth et al., 2013	PA counts/min or cpm (SD) 490 (135) in autumn, 447 (120) in winter, and 557 (175) in spring. MVPA in min/day (SD)	SB (min/day) 473 (63) in autumn, 486 (59) in winter, and 465 (66) in spring.	Sleep duration (min/night) 556 (27) in autumn, 553 (28) in winter, and	Not met in any season. About two thirds did not fulfil the physical activity recommendation of	Screen time was reported for only autumn (34%), so it is not comparable with the 24-hour Movement Guideline.	Met the guidelines across all seasons. Autumn is higher than winter and highest in spring.

Authors	MVPA by Season	SB by Season	Sleep by Season	Comparison of Group Means with 24-Hour Movement Guidelines		
				MVPA	SB	Sleep
	49 (23) in autumn, 44 (22) in winter, and 57 (27) in spring.		541 (30) in spring.	60 min MVPA per day. Spring is lower than autumn and lowest in winter.	However, they noted that about two thirds of the sample exceeded the screen time recommendation of <2 h per day.	
McCrorie et al., 2015	DPA measured as the number of steps taken in a season (Median)- (Mdn = 10,512) in winter and (Mdn = 12,879) in summer	Not assessed	Not assessed	Results are not comparable to the 24-hour movement guideline because of differences in units of measurement.	NA	NA
Nagy et al., 2019	PA (15 min MVPA, and 27 min LPA) in summer and spring. Winter (15 min MVPA, 38 min LPA) ($p < .001$).	SB = −42 min during summer and spring. SB = −53 min in winter.	Not assessed	Not met in any season. Winter is lower than autumn spring.	NA	NA
Pagels et al., 2016	Total PA in 2nd grade (min) - 113.9 (64.1) in September/autumn, 85.8 (43.6) in March/winter, and 128.8 (53.7) in May/spring. 5th grade (min) - 77.5 (41.5) in autumn, 57.6 (52.1) in winter, and 77.0 (45.1) in spring. 8th grade (min) - 42.3 (36.7) in autumn, 17.7 (14.5) in winter, and 60.0 (37.3) in spring. MVPA was reported in cpm (SD). MVPA outdoor counts were in September 112,679 (96,615), in March 66,476 (54,320), and highest in May 148,288 (138,689)	Not assessed	Not assessed	MVPA was reported in cpm, so it is not comparable to the guidelines. Autumn is lower than spring and lowest in winter.	NA	NA

Authors	MVPA by Season	SB by Season	Sleep by Season	Comparison of Group Means with 24-Hour Movement Guidelines		
				MVPA	SB	Sleep
	(*p* < 0.01). Indoor MVPA counts were in September 49,104 (52,033), in March 64,786 (61,225), and in May 42,823 (45,742), and thus highest in March (*p* < 0.001)					
North America Beighle et al., 2012	They had 2246 steps in autumn and 1450 steps in winter.	Not assessed.	Not assessed.	MVPA was not specifically reported. PA was higher in autumn than winter.	NA	NA
Brazendale et al., 2018	LPA (%of time) = Mean = 24.95 for school season, and 22.96 for summer. MVPA (%of time). Mean = 8.33 for school season and mean = 8.1 for summer. Total PA (% of time) Mean = 33.2 7 for school season and mean = 31.0 for summer.	Screen-time (minutes/day). Mean = 123.6 for school season and mean= 244.2 for summer.	Sleep (minutes/night). Mean = 413.8 for school season and mean =428.1 for summer.	Results are not comparable to the 24-hour movement guideline because of differences in units of measurement. School season is higher than summer.	Not met in any season. Summer is higher than school season.	Not met in any season. Summer is lower than school season.
Oreskovic et al., 2012	MVPA min per day. 36.4 min in spring compared to 1.7 min of MVPA/day in winter and summer (6.3 min of MVPA/day).	Not assessed.	Not assessed.	Not met in any season. Spring is higher than winter and summer.	NA	NA

Authors	MVPA by Season	SB by Season	Sleep by Season	Comparison of Group Means with 24-Hour Movement Guidelines		
				MVPA	**SB**	**Sleep**
Quante et al., 2017	PA assessed in counts per minute (cpm)= 1523 (363) in winter, 1684 (433) in spring, 1723 (484) in summer, and 1663 (397) in autumn.	Not assessed.	Sleep duration (min/night) 467.4 (42.5) in winter, 464.7 (40.4) in spring, 470.3 (41.5) in summer, and 461.9 (45.8) in autumn.	Results are not comparable to the 24-hour movement guideline because of differences in units of measurement. Summer is higher than spring and lowest in winter.	NA	Not met in any season. Summer is lower than winter and highest in spring.

Notes. DPA = Daily physical activity; LPA = light physical activity; MPA = moderate physical activity; VPA = vigorous physical activity; SB = sedentary behaviour. SD = Standard deviation, TV = Television. NA = No assessed/applicable, CPM = Counts per minute. Mean and *SD* values are reported as described in each study.

Chapter 5 Discussion

This section is focused on discussing the results in relevance to the aims of this scoping review. The objectives of this scoping review were to explore the influence of seasonality on movement behaviour in children and at the same time describe the current assessment devices and style of focus (i.e., isolated or integrative) used to examine movement behaviours. The objectives are therefore discussed alongside the findings from the literature reviewed.

An Insight into the Differing Seasonality Across the Globe

Although seasonal variations commonly occur in sync across continents, there are situations where seasonality in a particular country or part of a country is entirely different for other countries in the same continent. A typical example is that while the winter in most of North America has been reportedly cold and below zero degrees Celsius, Florida and North Carolina in the USA has long been described as having a warm winter with an average of about 65 °F (18 °C) (Dello et al., 2020). Other examples include parts of Canada with comparatively shorter daylight in the Northwest Territories (Prowse et al., 2009) and few parts of south-east Asia that receive regular snow, which does not happen in other parts of Asia (Kokhanovsky & Zege, 2004). Therefore, researchers studying seasonality should include adequate description of the seasons in the locations of their study to advance the research on seasonality.

The description of movement behaviour in terms of PA, SB and sleep has allowed research tofocus on singular or fewer combination of the movement factors for studies in the field of the effect of seasonality on children's movement behaviour (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007). The importance of movement behaviour research is further reinforced by the discussion of the importance of PA in children and the consequences of prolonged sedentary time (Saunders et al., 2016). To adequately address the gaps on the need for consistency in assessment devices (Rich et al., 2012), only studies with objective methodology were included in this scoping review, meaning studies that assess movement behaviour using interviews, surveys or other subjective measures were excluded. The outcome, thus, is a collection of studies that assessed movement behaviours in children using devices such as accelerometers and pedometers.

A Discussion on the Devices used for Movement Behaviour Assessment

Out of 14 studies, eight studies (Atkin et al., 2016; Deng et al., 2018; Hjorth et al., 2013; Nagy et al., 2019; Oreskovic et al., 2012; Remmers et al., 2017; Ridgers et al., 2015; Ridgers et al., 2017) noted that their accelerometers were worn around the hip while three noted that they were wrist-worn (Brazendale et al., 2018; Quante et al., 2017; Tanaka et al, 2016). Although one of the studies (Pagels et al., 2016) did not mention how their accelerometer was worn, this does allow further review as it is possible to have a single accelerometer that can be worn on the waist or hip depending on researcher's preference (Loprinzi & Smith, 2017). It is possible to question if more accurate seasonal variation would have been revealed if all the studies used waist-worn accelerometers since it is considered more accurate for assessing PA and SB in children (Lynch et al., 2019). But such queries will also have to be contrasted with children's adherence to wearing the devices since the wrist-worn accelerometer is considered more comfortable and therefore has better adherence than waist worn accelerometers (Fairclough et al., 2016). To resolve the issue of adherence versus accuracy, a wrist-worn accelerometer should be worn when a longer wear duration is required and hip-mounted when short but accurate wear duration is required. Only one study used pedometers as their measuring equipment (Beighle et al., 2012), and the authors reported data on LPA (i.e., number of steps taken). However, it opens the question of whether the researchers would have reported a different result if they had used accelerometers instead. The pedometer measure does not discredit the Beighle et al., (2012) study because they reported the data in which pedometers are fashioned to measure (i.e., steps taken). However, there are no specific LPA recommendations in the movement guidelines which could have helped to provide more deductions from the pedometer study (Beighle et al., 2012). The other 13 studies used accelerometers to assess movement patterns in children; however, only five of the studies reported SB measures (Atkin et al., 2016; Brazendale et al., 2018; Hjorth et al., 2013; Nagy et al., 2019; Tanaka et al., 2016), one reported on PA and sleep (Quante et al., 2017), while only two studies (Brazendale et al., 2018; Hjorth et al., 2013) included all three variables.

It has been noted that the ActivPAL^{TM} accelerometer can measure SB better than the Actigraph GT3X+triaxial accelerometer but it does not measure PA as accurately as the Actigraph GT3X+triaxial accelerometer (Ridgers et al., 2012). Only the McCrorie et al. (2015) study from the U.K used the ActivPAL^{TM} accelerometer from all the accelerometry studies. While the Actigraph accelerometers were mostly wrist-worn or waist worn in the studies, the ActivPAL^{TM} accelerometer was worn on the thigh. Mounting the ActivPAL^{TM} accelerometer on the thigh prompts the question of whether the thigh could be a better option for mounting accelerometers compared to the wrist and waist. Majority (i.e., 11 out of 13) of the studies used the Actigraph GT3X+triaxial accelerometer. Even though accelerometers are already equipped to measure PA and SB simultaneously (Lyden et al., 2017), out of the 14 studies, 13 measured movement behaviours with accelerometers, but only five reported SB measures for the children

(Atkin et al., 2016; Brazendale et al., 2018; Hjorth et al., 2013; Nagy et al., 2019; Tanaka et al., 2016), and one reported on PA and sleep (Quante et al., 2017).

Considering that an accelerometer can generate data for PA and SB simultaneously (Loprinzi & Smith, 2017), it is unclear why out of 14 studies, eight studies did not report SB measures. This is apart from the fact that some accelerometers include light sensors (Loprinzi & Smith, 2017), which can contribute towards the assessment of sleep as a movement behaviour (e.g., if the children slept with lights off), but sleep was not assessed by 10 out of 13 accelerometry studies. Maybe the studies did not have an all-inclusive focus for movement behaviours, but a collective focus appears to be the growth path for the literature on seasonality and movement behaviours. The accuracy of accelerometers contributes to why accelerometers are the preferred instrument of measure (Loprinzi & Smith, 2017), and it is encouraging that most of the reviewed studies used it. The inclusion of all movement behaviour measures derived from accelerometers would have allowed putting the findings in a similar context for comparison and analysis in the scoping review. Therefore, future accelerometry studies should provide a collective analysis for PA, SB and sleep for more informed reviews.

The Impact of Seasonality on Isolated Versus Integrative Movement Pattern in Children

Based on information gathered from the scoping review of the 14 studies selected, seasonality appears to have a significant impact on movement behaviour in children. Although this review advocates for more studies on SB and sleep, alongside PA, to provide a multifaceted picture of movement behaviour in children, the discussion below is broken into the movement behaviours at first before summarizing and describing the overall picture of the review. Because the age-range for inclusion in the scoping review is between 5 to 14 years old, most of the study participants are school children. The age bracket selection of 5 to 14 means that apart from studies that span through all the seasons, including the holidays, most studies assessed children while in school except during summer. Fortunately, some of the studies include all the seasons and also some studies assessed PA during the weekends (Atkin et al., 2016) when children are not in school.

Physical Activity

All of the studies reviewed assessed PA in children either singularly or paired with other movement behaviours allowing for a better insight into PA in children. The PA opportunities for children in the review included unstructured PA in the playgrounds during a break at school to sporting and other organized activities structured into the schedule or curriculum. Considering that children spend most of their weekdays at school (i.e., most of the morning to afternoon hours) which is a major portion of daylight hours, the expectation is that the effects of seasonality would have been an addition to school influence. School influence was accounted for in most of the research studies from Europe (Atkin et al., 2016, Deng et al., 2018; Hjorth et al., 2013; Nagy et al., 2019; McCrorie et al., 2015; Pagels et al., 2016). It is also revealed that PA seasonal variations was increased in summer compared to other seasons (Atkin et al., 2016, Deng et al., 2018; Hjorth et al., 2013; Nagy et al., 2019; McCrorie et al., 2015; Pagels et al., 2016). However, in some cases, spring had a higher PA compared to summer (Brazendale et al., 2018). The possible inferred reasons for these ranges from the absence of school structure and environment at home such as the absence of large playground or other children to play with (Atkin et al., 2016).

Another concept discussed in relevance to seasonal variations in movement behaviour is how seasonality influences children's going outdoors and thereby influences their PA (Pagel et al., 2016). The outdoor effect was most notable in the study conducted in Europe (Pagel et al., 2016), where an increase in the rate at which the children went outdoors during summer correlated with the increase in their overall PA. The same outdoor component was reported in an American study, which noted that the children that engaged more in PA in winter also went outdoor more in winter, suggesting the outdoor component as the reason for increased PA (Oreskovic et al., 2012). This behavioural change was also reported to align with the rising temperature and increased daylight experienced in summer, which is comparatively higher than other seasons in the year and therefore encourages children to go outdoor in Japan (Tanaka et al., 2016). The seasonal variations in Japan were compared slightly differently, such that summer was compared to any other seasons (i.e., spring, autumn and winter) in the school year for children (Tanaka et al., 2016). They still reported similar variations with the studies in Europe. They reported PA peaking in summer compared to the rest of the year (Tanaka et al., 2016). It is noteworthy that a preceding systematic review (Tucker & Gilliland, 2007) noted that outdoor effect is a promoting factor for PA making it a considerable factor for future seasonality studies.

An almost directly opposing report was issued by the studies carried out in Australia. In Australia, children achieved the highest PA in winter and spring compared to summer and autumn (Remmers et al., 2017). However, it is necessary to note the weather parameters that define a season in Australia is quite different from Europe. For example, winter occurs between June to August with an average temperature of about 17°C/63°F (Remmers et al., 2017; Ridgers et al., 2017; Ridgers et al., 2015) while the average temperature of winter in Europe goes well below negative values (McCrorie et al., 2015). The weather difference between Europe and Australia implies that a sunny winter day in Australia could be comparable to a sunny summer day in Europe and raises the question of whether seasonal comparisons should be broken down to the weather elements. The spring and summer heat was noted as the reason why PA was lower in summer compared to winter in Australia (Ridgers et al., 2015). From the title “Too hot to move” (Ridgers et al., 2015) the summer heat of Australia is linkable to the reduced activity in children.

A hindering factor to the weather description is the fact that the seasons are still termed similarly (i.e., winter, summer, spring, and autumn). A study with 2015 children participants aged 6 to 12 years in Norway, Europe (Kharlova et al., 2020) using accelerometry also reported that children achieved more MVPA during the warmer months of September to October (summer and autumn) compared to the colder January to June (Winter and spring). The Kharlova et al., (2020) study also noted that positive changes as little as five degrees Celsius increase in temperature was associated with over an hour increase in MVPA in the participants. This further raises the suggestion that PA varies with temperature in places with extremely cold climate and could be an area of focus to improve PA in children. Therefore, focusing interventions on parts of the year with the lowest temperature might promote PA in children.

With the knowledge that schools, as a place where children spend a large portion of their time, play a major role in influencing movement behaviour and being a constant factor across the continents, the influence of seasonality at school and at home is therefore equally considerable in both contexts. There are also different weather variables that might be experienced only in particular places in the world, for example, the heavy snowfall in parts of Europe and North America or the lack of snowing seasons in parts of Asia. Therefore, the suggested measure is to follow the definition of seasonality in each geographical zone and recognize the behaviour pattern of children in association with the seasonal variation, thereby creating a customized perspective that fits best with geographical zones with similar seasonality. Furthermore, the recognition of various seasonality descriptions can help address the stark difference in seasonality that occurs both within and across continents.

Sedentary Behaviour

The sedentary behaviours exhibited by children in this review ranged from screen-time, which is the time spent on devices such as the television, mobile phones, iPods, tablets, and other similar screen devices, to time spent in any other behaviour that does not include PA or sleep (Tanaka et al., 2016). While the Canadian 24-hour movement guidelines have specific recommendations for only screen time, most of the studies did not report screen time. Therefore, this scoping review discusses patterns of SB which may or may not include screen time.

The seasonal variation report provided for SB appears to occur in reverse to PA. For example, the European studies (Atkin et al., 2016; Hjorth et al., 2013; Nagy et al., 2019) show that compared to spring and autumn, sedentary time was lowest in summer when PA time was at its highest. However, in winter, SB was at its highest, while PA was at its lowest. Studies in Australia provided the same PA and SB report, however, in this case, the seasonal influences were reversed with PA time peaking in winter while SB was at its lowest, and the case was reversed as summer was approached (Remmers et al., 2017). The reports allow conclusions that PA and SB have a likely inverse relationship with seasonal variation, (i.e., when the season encourages children to be more active, sedentary time is decreased). SB also appeared to be negatively correlated to PA in the systematic review that included it as a movement behaviour that was reviewed (Rich et al., 2012). However, when the season discourages them from engaging in activities via low temperature in Europe for example (Hjorth et al., 2013), PA time can be diverted towards SB. The diversion of PA time towards SB suggests that in the integrative view of movement behaviour interaction in children, sleep could be more of a constant while SB and PA are inversely related. However, it is not possible to conclude the relationship between PA, SB, and sleep as we have less than half of the studies selected reporting SB measures and only three studies that reported sleep measures. Such situation further highlights the purpose behind encouraging the study of all the movement behaviours in unison rather than solitarily.

Sleep

Only three studies reported on sleep variations with seasonality in children; therefore, there is less basis for comparison. The first study from Denmark, Europe that reported on sleep also provided reports on PA and SB and showed that children slept two percent more in winter compared to spring (Hjorth et al., 2013) which was not statistically significant but warrants further research to determine its clinical significance. The Hjorth et al., (2013) sleep report follows a similar pattern with SB in that sleep varies inversely with PA, but it is unclear if the pattern would have been repeated with other studies from Europe.

The second group of studies that reported on sleep were from Massachusetts and the southeastern part of USA (Brazendale et al., 2018; Quante et al., 2017). These studies provided a supporting report to the Hjorth et al., (2013) study but added the fact that children stayed awake for a shorter time when they went to bed in winter compared to summer (Brazendale et al., 2018; Quante et al., 2017). The results show that although winter encourages more SB and does not promote PA, it tends to be more suitable for sleep possibly because it offers longer and colder nights than other seasons (Brazendale et al., 2018; Quante et al., 2017). Brazendale et al., (2018) showed that the children had longer sleep duration in summer when compared to winter contrary to other studies with similar climates. This points to the possibility that if sleep is not a constant factor when it comes to seasonal variations, then it most likely would vary in a similar pattern to SB but in opposition to PA. This conclusion that sleep varies similarly to SB is once again hard to reach because there were only three reports on sleep and from two continents. The intra-continental comparison is also not as informative as findings are similar, which is expected since the studies were conducted in locations with similar seasonality.

A Comparison of the Scoping Review with Preceding Reviews

Although the initial plan was to include all quantitative and qualitative studies on sleep, this scoping review ended up sharing similar views with the preceding reviews (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007) in terms of sourcing only studies with objective assessment. There were no other studies found on sleep, be it objective or otherwise apart from the three quantitative studies (Brazendale et al., 2018; Hjorth et al., 2013; Quante et al., 2017). However, this can be considered as an improvement as the first sleep studies to be included on the topic of seasonality versus movement behaviour in children.

Apart from the movement behaviours reviewed, the distribution of results found was similar, with most studies coming from Europe, North America, and Australia. However, the difference in the number of movement behaviours studied in each review led to the difference in the number and variety of studies and likely is the reason why this scoping has a comparable number of studies included despite focusing on a shorter span of eight to nine years. The increased number of studies despite a shorter collection period of eight years indicates that more research is ongoing on the effect of seasonality on children's movement behaviour, but the research is spreading slowly to African, South American and Asian parts of the globe. All the systematic reviews reported that seasonality played an essential role in influencing movement behaviour (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007), and this scoping review supports it. Specifically, PA showed variations with weather variables throughout all the studies in this scoping review. PA is easier to compare because all the previous systematic reviews researched at least PA, and most of the individual studies in this scoping review also focused on PA as well. The scoping review shows that children have reduced PA in seasons described as less conducive for activities, especially outdoor activities.

Spring and autumn however did not show significant difference in how they influence movement behaviour which is similar to the reports from the preceding reviews (Carson & Spence, 2010; Rich et al., 2012; Tucker & Gilliland, 2007). Seasonal variability, however, could not be further researched due to inadequacy of data and the fact that some of the studies had classed spring and autumn as one, for instance, reporting them as “other months” or “spring/autumn” (Beighle et al., 2012). Clearer definitions should be made for seasonality in future studies with focus on all seasons regardless of similarities or differences in the weather variables attributed to the seasons (e.g., “spring of school” year instead of just “school year”). The conclusive information compared with preceding reviews is that just like PA, seasonality influences SB.

Unlike SB and PA, none of the previous systematic reviews explored sleep. The lack of sleep research, therefore, reveals the need for not only more studies on SB but even more focus on sleep. The scarcity of sleep studies would have allowed for even better comparison of studies on sleep and how it could have related to the other movement behaviours in the past years between this scoping review and past systematic reviews. Movement behaviour recommendations that currently include the three movement behaviours as seen in Australia, and Canada (Department of Health, Australia, 2019; Tremblay et al. 2016). In the past years, the was almost no consideration for sleep but currently this scoping review shows three studies looked at sleep alongside other movement behaviours. It can be anticipated that this integration will continue to advance as literature on integrated movement behaviours grows. Having a global standard for recommendations and surveillance data would help towards the understanding of the global state of affairs and how seasonality influences variability (Tremblay et al. 2016). Nevertheless, there were traditional guidelines for PA (WHO, 2010) and SB (Tremblay et al., 2011) published earlier which the studies could have compared their findings with like the Hjorth et al. (2013) study. However, the inclusion of two studies that includes all three movement behaviours indicated the possible advancement of research in the effect of seasonality on children's movement behaviour towards the integrative direction.

As revealed in the scoping review, only one of the studies compared their findings against a movement guideline and showcased a side-by-side comparison of the effect of seasonality on the movement behaviours (Hjorth et al., 2013). They created an opportunity to simultaneously compare the influence of seasonality in multiple movement behaviours (Hjorth et al., 2013). The all-inclusiveness of movement behaviours also further provides a better view on how an individual variation on a particular movement behaviour could affect other movement behaviours (Hjorth et al., 2013). For example, while the children achieved less MVPA hours in winter, they accumulated more SB and sleep time (Hjorth et al., 2013).

Implications of the Research

Significance

This review reveals the scope of literature on this topic since the last review published eight years ago (Rich et al., 2012). Such information is useful in the development of interventions to promote meeting the 24-hour Movement Guidelines through the creation region specify interventions customized for specific seasons across the globe. It can also serve as a possible reference point for public health decision making and the pursuit of further related research by providing an updated knowledge map on this topic. The knowledge map displays the variations in seasonality against the variations of movement behaviour in children. Decision makers can look at how seasonality affect different parts of the world and pin-point seasons that need specific interventions (e.g., the creation of indoor games during winter in Europe to promote PA).

Since studying the movement behaviours in an integrative fashion has allowed a clearer perspective on how inadequacies in any of the movement behaviours could affect the overall movement patterns (Carson et al., 2016), this will also contribute to the progress of studies in the supported direction (i.e., collective, or integrative research focus on movement behaviours) by showing advancements on the topic. The results can also inform the development of public health initiatives and policies geared towards promoting movement behaviours to meet the guidelines (e.g., increasing the PA scheduled into the timetable at schools during winter in Europe).

The knowledge that was deducted from this scoping review adds clarity to the current role of seasonality on children's movement patterns and helps decide on the trajectory of future research and intervention in the field of movement behaviour towards a more integrative style of study. Being conducted after the establishment of the evidence-based movement guideline for children, it will also serve as a reference point on the influence of seasonality on movement behaviour since the inception of the new all-encompassing 24-hour Movement Guidelines (Tremblay et al., 2016). This review emphasizes areas where further research is required which are more studies on SB, sleep, and more integrative studies. For example, it appears that while there are enough studies for a systematic review on PA, more research is needed on SB and sleep.

Limitations

This scoping review provides relevant updates to the field of seasonality and movement behaviour in children; but also possesses a few limitations in this scoping review includes the exclusion of articles not published in English and exclusion of qualitative studies and self-report studies conducted on PA and SB narrows the focus of the review but increases its specificity. Grey literature was not included in the review because they are not peer-reviewed (Paez, 2017) and thus, do not qualify for inclusion. Additionally, grey literature would have limited the ease of replicability of this review and can make it difficult to trace the included studies. Limiting the search to only quantitative studies and only to three specific platforms (PubMed, MEDLINE and SPORTDiscus) while excluding truncation of search terms and self-report studies are also limitations of this scoping review because they could have influenced the search process. The specificity of this scoping review however, increased because only studies with comparable content that address the gaps noted by the last review (Rich et al., 2012) were analyzed and discussed.

Additionally, this review promotes easier quantitative comparison with future studies on the topic of seasonality versus movement behaviour in children. It was recommended that two researchers code the studies for scoping review (Peters et al., 2020), however only the author of this scoping review completed the coding after the inter-rater reliability check with a fellow junior researcher in the North PA lab of Nipissing University. Having only the author code the studies however prompted the need for repeat-coding to improve verification of the process and also provides a centralized path for future inquiries. The JBI protocol includes an optional consultation step (Peters et al., 2020), but since it is only optional, it was not conducted in this scoping review.

Future Directions on Seasonality and Movement Behaviours in Children

Seasonality in Africa and South America and Impact on Children Movement Behaviour

This scoping review was geared towards including studies from all continents across the globe however at this time no studies from Africa and South America met the criteria to be included in the review. However, there are reasons to believe that seasonality in Africa and South America can be influential in children's movement behaviour in those regions. Seasonality in Africa is usually based on cyclical periods of wet (i.e., rainfall season) interchanged with dry season across the year, with this cycle differing in the period of occurrence across the vast continent (Dunning et al., 2018). For example, in East Africa, the frequency and duration of rainfall increases between December to February, making the weather cooler than most other periods of the year (Dunning et al., 2016). The wet season is usually followed by three to four months of the dry season that starts cold towards the end of February to warm in April, May, and June to the point that it is intercepted by rainfall around July/August, which cools it down, but it warms up gradually towards November repeating the cycle all over (Dunning et al., 2016). A similar pattern but with different variations are repeated across the country for example, while West Africa may have a replica of the seasonality in East Africa, North Africa has a more prolonged dry season, and rainfalls can occur at a different calendar month, which is replicated in an opposite pattern in South Africa (Dunning et al., 2018).

While about 48% to 51.7% of children in South Africa met the MVPA recommendations (Tomaz et al., 2020), up to 67% exceeded the recommendations for sedentary behaviour due to the time spent on screen time alone (Draper et al., 2018). About 81% of the children met the sleep guideline on weekdays, but the number decreased to 75% on weekends (Tomaz et al., 2020). Although minimal variations in movement behaviour are anticipated because of the comparatively reduced number of seasons, it would have been informative to reveal such variations and compare them with variations from other parts of the globe. The lack of a seasonality component to the Tomaz et al. (2020) study however prevents further comparison with the studies reviewed. An accelerometry study that included 40 adolescent girls aged 13 to 14 years from Senegal in Africa reported a higher PA during the rainy season compared to the dry season (Bénéfice & Cames, 1999). The variations in rainy season versus dry seasons suggests that seasonality also influences movement behaviour in Africa and thus, more studies should be conducted.

Seasonality in South America follows biannual fluctuation similar to Africa except that the peaks and troughs of the weather variables can be different depending on the regions compared (Bombardi et al., 2018). There is also a notable precipitation factor, especially in the northern part of South America, that varies alongside the rainfall component throughout the year (Bombardi et al., 2018). However, due to the inadequacy of quantitative publication on the topic in Africa and South America, seasonality and movement behaviour conclusions and assumptions cannot be made. Therefore, for better analysis, more studies from Africa, Asia, and South America on seasonality's influence on children's movement behaviour are required for progress in the research field of the effect of seasonality on children’s movement behaviour. The need for more studies is also extended to studies on SB and sleep as equally important movement behaviour in children. It will also be educative to have more studies from countries with variable seasonality within the country. For example, despite using the Canadian movement guideline, there was no study from Canada specifically in this scoping review which could have helped towards showing variable seasonality and movement behaviour in North America.

General Recommendations for Advancing the Literature

In accordance with the socio-ecological model which shows that children's behaviour could be influenced directly or indirectly at the individual, family, and community level (Ohri-Vachaspati et al., 2014), other influential factors such as family and societal culture should be researched for possible influence on children's movement behaviour. To further research seasonal influence on children's movement behaviour, seasonality can be broken into weather elements such as temperature and humidity and researched to see how they influence children's movement behaviour. Knowing how individual weather elements affect movement behaviour in children might better explain ecological impacts on children's movement behaviours. Broad concepts such as weather, family, and societal influences on children movement behaviour can be examined using a scoping review and can build on the findings from this scoping review. The publication of more quantitative studies examining all three movement behaviours (i.e., PA, SB, sleep) can also contribute towards the conduct of another systematic review.

Subsequent studies should be progressive by studying movement behaviours collectively, including sleep, and comparing their findings with a movement guideline to provide a clearer interpretation of their results. The absence of SB data reports despite the availability of SB assessment accelerometers shows the possibility that there is an opportunity to better utilize and interpret data collected and improve data collection efficiency. The integrative focus on movement behaviour exhibited in this scoping review also allows the revelation of the fact that while a particular movement behaviour is not met (e.g., less than one hour of MVPA daily), other movement behaviours, sleep, for example, could be met or exceeded. Such variations also occur seasonally, which opens the question of whether interventions on movement behaviour should be customized to optimize meeting specific movement behaviours in the movement guidelines.

In summary, while this scoping review demonstrates the influence of seasonality on movement behaviour in children, this has further revealed study options to progress in this field of research. The study options include conducting more studies in Asia, Africa, and South America and why many accelerometry studies do not assess SB despite having devices that might be equipped to do so. Having more globally distributed studies will allow for better reviews and provide relevant data for comparative reports such as the ranking in the global matrix. Context such as seasonal, school structure and cultural associations are also important for better understanding and interpretation of seasonality and movement behaviour reports.

Chapter 7 Conclusion

This scoping review shows that seasonality may impact movement behaviour in children across some parts of the globe. The effects range from promoting engagement in particular movement behaviours (e.g., increased PA in summer in Europe) or impeding children from movement behaviours, such as reduced PA during summer in Australia. The studies reviewed were from Australia, Europe, USA in North America, and Japan in Asia.

Except for one pedometer study, most objective studies used accelerometers to assess movement behaviours in children, therefore, allowing easy comparison of the studies. There is also speculation on whether more accurate results would have been reported if all the studies used waist-worn accelerometry since it is considered more accurate (Lynch et al., 2019). However, wrist-worn accelerometers have shown more compliance in children, and thus may be preferred tools in this age population. It is therefore advisable that wrist-worn accelerometers be used when extended activity data collection time is required while hip-mounted versions can be employed for best accuracy in a short duration.

Part of this review objective was to show how many studies currently embrace the more descriptive all-inclusive study technique for children's movement behaviours. While the studies reviewed show that research is trending towards that integrative direction, there are still more studies on isolated movement behaviours versus those that include all the movement behaviours. Specifically, eight studies focused only on PA, four studies focused on two movement behaviours with only one of them looking into PA and sleep while only two studies integrated all the movement behaviours.

Although there was insufficient information to confirm that seasonal influences determined meeting movement recommendations in each of the countries where the studies were carried out, the statistical significant values reported by the reviewed studies suggested that seasonality can influence children towards meeting the guideline or not meeting the guideline. Additional studies will be needed to make further understand whether seasonality influences the extent to which children meet the movement guidelines.

Conclusively, this scoping review on seasonality's influence on children's movement behaviour has contributed to mapping out the available literature to reveal the current scope on this topic. This review has also updated the literature on the body of knowledge regarding the concept of seasonality and movement behaviour in children. The results and interpretation provided serves as part of the foundation for a progressive study and development in seasonality and movement behaviour research. Studies that can progress research on the field of seasonality and movement behaviour in children include studies on weather correlates and movement behaviour and studies that look into other activity influencers such as family impact and neighborhood influence. Other examples of progressive succeeding studies can be a systematic or scoping review on SB and sleep as under-researched movement behaviours in the context of seasonality, or a study which integrates all the movement behaviours in connection with seasonality in children.

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Appendix A

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	i-iii
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	iv
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	1-28
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	28-29
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	N/A
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	29-32
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3-35
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	35
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	30-37
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms and any processes for obtaining and confirming data from investigators.	40-42
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	47-50
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the	NA

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
		methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	38
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	38
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	38-40
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	NA
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	47-50
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	38
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	51-55
Limitations	20	Discuss the limitations of the scoping review process.	77
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	82-84
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	NA

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. DOI: 10.7326/M18-0850.

Appendix B

Declarations

There was no conflict of interest in the conduct or report of this scoping review. This project is also not funded by an organization or sponsored by a company and therefore does not include any promotional content. The primary objective of this material is for education, research, and knowledge translation purposes.

Appendix C

Ethics

This scoping review does not require an approval from Nipissing University Research Ethics Board (NUREB). It does not require safety assessment for contact with participants or poses any threat that requires ethical consideration.

However, the TCPS-2 tutorial was completed prior to the conduct of this scoping review, and the certificate is available upon request.