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Review

# The physical activity levels of preschool-aged children: A systematic review

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ABSTRACT

This systematic review presents research on the physical activity levels of preschool-aged children (aged 2–6 years). Thirty-nine primary studies (published 1986–2007) representing a total of 10,316 participants (5236 male and 5080 female), from seven countries are described and the physical activity behaviors of this population are considered in accordance with the National Association for Sport and Physical Education (NASPE) physical activity guidelines for preschoolers. Upon review of the evidence, it is apparent that nearly half of preschool-aged children do not engage in sufficient physical activity. Current recommendations suggest a minimum of 60 min of physical activity per day; only 54% of participants throughout the studies achieved this. Furthermore, as with other age groups, boys participate in considerably more physical activity than girls. It is clear from this systematic review that nearly half of children studied are not meeting the recommended guidelines for physical activity. Therefore, effective interventions that promote and foster physical activity in children are necessary, especially in females. However, a more objective physical activity guideline for preschoolers is necessary; measurement of activity needs to become more unified to compare and track activity more effectively.



**Contents**



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## 1. Introduction

Physical activity is important to integrate into the lives of children and adolescents. It sets the foundation for facilitating and maintaining healthy active living through adulthood (Cragg & Cameron, 2006; Stolley et al., 2003), and physical activity levels have been shown to track from year to year (Pate, Baranowski, Dowda, & Trost, 1996). Specifically, the physical activity behaviors of preschoolers have been identified as similar or the same as activity levels during their childhood years (Pate et al., 1996). Therefore, the importance of establishing healthy and appropriate behaviors while children are young is crucial for long-term effects.

Physical activity provides a number of health benefits, both physical and psychological (Cragg & Cameron, 2006; Warburton, Nicol, & Bredin, 2006). In addition to prevention and reduction of childhood overweight and obesity (which now affects 25% of Canadian children; and 22 million children under the age of 5 worldwide) (Canning, Courage, & Frizzell, 2004; WHO, 2008), physical activity has been associated with cardiovascular health and fitness, muscular strength and endurance, reduction in depression and anxiety, and a positive association with academic achievement (Strong et al., 2005). However, despite the numerous documented benefits of regular physical activity, 60% of Canadian children and youth (aged 5–17) are not sufficiently active to gain such health benefits (Canadian Fitness and Lifestyle Research Institute, 2005), and 22.6% of American children do not engage in any free-time physical activity (CDC, 2003). Furthermore, physical activity levels have been shown to decline with age, decreasing from 49% in younger children (5–12 years of age) to 36% in older adolescents (13–17 years of age) (Cragg & Cameron, 2006; Craig, Cameron, Russell, & Beaulieu, 2001). Therefore, effective interventions to target these vulnerable groups are important.

Teachers and parents previously assumed that preschool-aged children are very active (i.e., continually running around) and have concluded that young children engage in sufficient activity (Benham-Deal, 1993a; Sallis, Patterson, McKenzie, & Nader, 1988). However, researchers believe that the amount of time that children spend at daycare, the increases in television viewing, the fact that children have fewer siblings to play with than children of previous generations, and the greater parental constraints in play places and safety concerns have resulted in dramatic increases in sedentary behavior (Boreham & Riddoch, 2001; Davies, Gregory, & White, 1995; Poest, Williams, Witt, & Atwood, 1989; Salbe, Fontvieille, Harper, & Ravussin, 1997). Therefore, parents and teachers' potential overestimation of physical activity levels in children may result in a decreased emphasis placed on the importance of encouraging and supporting active lifestyles in this age group.

Recently, the National Association for Sport and Physical Education (NASPE) released physical activity guidelines specific to preschoolers recommending at least 60 min of physical activity and up to several hours of unstructured play per day (National Association for Sport and Physical Education, 2002). The guideline was created by the Active Start committee, consisting of motor development experts, movement specialists, exercise physiologists, and medical professionals. This physical activity recommendation is the best currently available guideline against which to compare preschoolers' physical activity levels. Therefore, the purpose of this paper was to systematically review the relevant literature to assess the extent to which preschool-aged children (aged 2–6 years old) are sufficiently physically active in accordance with the NASPE guideline. Sufficiently active children are, therefore, operationalized as those who engage in at least 60 min of moderate to vigorous physical activity (MVPA) per day. Sex differences and measurement differences will also be explored. This is the first study to analyze the literature in accordance with the current NASPE physical activity standards. The results of this review are of particular importance for determining an accurate reflection of physical activity participation among this population and, consequently, identifying the importance of early physical activity interventions.

## 2. Methods

In an attempt to acquire all relevant literature (published between 1980 and 2007) for this systematic review, computerized searches of eight databases were conducted: Medline; CINAHL; Proquest; PsychInfo; the Physical Activity Index; Web of Knowledge; Child Development and Adolescent Studies; and Pubmed. The search terms used to identify the chosen articles were: physical activity; motor activity; exercise; preschoolers, children and nursery school. The reference lists of appropriate articles were also reviewed, and additional literature was appraised and retrieved. Eighty articles were deemed potentially appropriate and consequently, the abstracts, introductions and methodologies of each study were examined to assess the purpose, method and sample for possible inclusion in this systematic review. Studies were excluded from further consideration if they were not written in the English language ($n = 3$, 7%), if they utilized qualitative methodology only ($n = 3$, 7%), if the results were not clearly representative of preschoolers (i.e., the sample included children 4–10 years of age; $n = 12$, 23%), if the sample was comprised of preschoolers with a specific ailment ($n = 5$, 12%), if the physical activity measurement was after an intervention ($n = 3$, 7%), or if they did not actually report the physical activity level of the preschoolers (i.e., instead the authors validated a tool, compared variables, etc.; $n = 15$, 35%). Consequently, a total of 39 studies, summarized in Table 1, were deemed relevant, given that they met the criterion of being primary studies in which the physical activity behaviors of preschool-aged children were appraised in a quantifiable manner.

An additional number of studies ($n = 14$, 33%) were not included in this systematic review because appropriate cut off values or guidelines for interpreting the data were not provided (i.e., the authors documented physical activity level (e.g., 777 counts per minute), but did not provide guidelines for interpreting the results). Without comparison guidelines to judge the level of activity, these data provide no further information regarding preschoolers' behavior.

**Table 1**
Preschoolers' physical activity behaviors

| Author, date | Participants | Assessment method | Physical activity guidelines used to define moderate to vigorous physical activity | Physical activity level | Majority of participants sufficiently active (based on the NASPE guidelines) |
|---|---|---|---|---|---|
| Baranowski, Thompson, Durant, Baranowski, & Puhl (1993) | 191, 3 and 4-year-old American children, Boys = 90, Girls = 101 | CARS direct observation | 1 = stationary, 2 = stationary trunk, but limb movement, 3 = slow trunk movement, 4 = moderate trunk movement, 5 = fast trunk movement | Boys were more active than girls. Mean activity score for females ranged from 1.77 to 1.99 for indoor activity and 2.19–2.51 for outdoor activity. For boys, mean activity score ranged from 1.82 to 2.02 for indoor activity to 2.16–2.69 for outdoor activity | No |
| Benham-Deal (2005) | 39 American children, aged 3–5 years, Boys = 19, Girls = 20 | Polar Vantage XL heart watch | NASPE guidelines | 71% of the children meet the NASPE guidelines on the weekdays, fewer (46%) on weekends. 85% of the weekday episodes and 76% of the weekend periods fell within the 5–10 min range | Yes |
| Benham-Deal (1993b) | Experiment #1–12, 3–5-year-old American children, Boys = 3, Girls = 9<br>Experiment #2–18, 3–5-year-old children, Boys = 9, Girls = 9 | Polar Vantage Heart Watch | <129 beats per minute (bpm) was considered low activity level. >130 beats per minute or 60% of their max heart rate was considered MVPA | Experiment #1, minimal and maximal heart rates ranged from 76 to 206 bpm. At home, heart rates reached moderate or vigorous levels for 25-31.5% of the time, with 1.6–4.4% at vigorous intensities<br>Experiment #2, Nearly 22% of their time, from 9 to 11 am was engaged in MVPA. From 11 am until bedtime, 90% of their time was spent in low activity. | Yes |
| Burdette, Whitaker, and Daniels, 2004 | 250 American preschoolers, aged 29–52 months, Boys = 143, Girls = 107 | Accelerometer and a checklist recording daily outdoor play time | | Children spent a mean of 146 min/day playing outdoors based on the outdoor playtime recall checklist. Accelerometers documented a mean of 667 vectors per minute | Yes |
| Burdette and Whitaker (2005a) | 3141 American mothers reported on their preschoolers, mean age 39 months, Boys = 1665, Girls = 1476 | Parents were asked to recall the number of hours their child typically spends playing outdoors. | | The children spent more time playing outdoors on weekends than weekdays ($p < .001$). Children spent an average of 156 min outdoors on weekdays and 226 min on weekend days | Yes |
| Cardon and De Bourdeaudhuij (2007) | 122 preschoolers from Belgium, Boys = 59, Girls = 63 | Digiwalker pedometer, Actigraph accelerometer, and diaries | NASPE guidelines | Average daily step count was 9980 with no significant sex differences. Children took 18.68 steps/minute. 60 min of MVPA = 13,874 step counts, and only 8% (or 10 children) reached this | No |
| Dowda, Pate, Trost, Almeida, and Sirard, 2004 | 266 American children, aged 3–5 years, from nine different preschools, Boys = 126, Girls = 140 | Observation System for Recording Activity in Preschoolers (OSRAP) | NASPE guidelines | When children were observed outside, they engaged in MVPA about 27% of the time. This means that on average, children with 2, 1-h outdoor play periods would accumulate 32 min of MVPA | No |
| Durant et al. (1993) | 180 American 3 and 4-year-old children, Boys = 82, Girls = 98 | Direct observation, Children's Activity Rating Scale (CARS) | >120 bpm was considered physically active | Boys were significantly more active than girls. Children's highest percent of time in activity was between 5:00 and 5:59 pm which represented 54.58% of the time. Activity in just category 4 and 5 was highest from 6:00 to 6:59 with 13.7% of minutes | No |
| Finn, Johannsen, and Specker, 2002 | 214 American preschoolers, aged 3–5 years, Boys = 108, Girls = 106 | Actiwatch activity monitor | A cutoff of 1000 counts was defined as a minute of vigorous activity | Time spent in vigorous activity was 4.5% for girls and 5.2% of boys per day, a significant difference ($p < .02$). This would translate into approximately 32 and 37 min of vigorous activity for girls and boys, respectively | No |
| Finn & Specker (2000) | 40, 3 and 4-year-old American children in a childcare setting, Boys = 16, Girls = 24 | 6 h of observation (CARS) and 48 h of motion sensor measurements (Actiwatch) | Levels 1–5, levels 4–5 are moderate and vigorous | CARS scores showed a mean of 1.6 of the total observation period. CARS scores of less than 2.0 were recorded 66% of the time, scores of 2.0–2.9 were recorded 26% of the time. Only 5% of the total time was the CARS score between 3.0 and 3.9 and slightly less than 1% of the time was the score greater than 4.0 | No |

Table 1 (*Continued*)

| Author, date | Participants | Assessment method | Physical activity guidelines used to define moderate to vigorous physical activity | Physical activity level | Majority of participants sufficiently active (based on the NASPE guidelines) |
|---|---|---|---|---|---|
| Fisher et al. (2005a) | 394 preschoolers from Glasgow, Scotland, Boys = 209, Girls = 185 | CSA acclerometer | MVPA >3200 counts per minute | MVPA was relatively low, averaging 3.4% of time, with MVPA being significantly higher in boys than girls. This translates into approximately 25 min/day | No |
| Fisher et al. (2005b) | 209 preschoolers from Glasgow, Scotland, Boys = 101, Girls = 108 | CSA accelerometer | MVPA >3200 counts per minute | Physical activity was recorded in 2.7%, 3.8%, 4.1% and 2.1% of their day in spring, summer, fall and winter, respectively | No |
| Goran et al. (1998) | 22 American preschoolers, Boys = 11, Girls = 11 | The Doubly Labeled Water method and an activity questionnaire | Activity energy expenditure was estimated as the difference between total energy expenditure and resting energy expenditure | Hours of activity were 7.1/week for boys and 5.6/week for girls | Boys = Yes, Girls = No |
| Hands et al. (2006) | 24 children, mean age of 3.5 years from Perth, Australia, Boys = 12, Girls = 12 | The Digiwalker pedometer, Actigraph accelerometer and a direct observation tool (CARS) | A CARS score of 443 or below was considered an overall activity level of low, between 443 and 490 was medium activity level and over 490 was considered high or vigorous activity level | Boys were significantly more active than girls on all three measures of activity. Mean counts for accelerometers was 58,388, pedometer was 1145 and 467 for direct observation. 3 boys and 4 girls were categorized in the medium activity group and 7 boys and 1 girl were grouped in the high activity level | Yes |
| Jago, Baranowski, Baranowski, Thompson and Greaves (2005a) | 149 American participants, aged 3 and 4 years old, in year 1, 141 in year 2 and 136 for year 3, Boys = 73, Girls = 76 | The Studies of Children Activity and Nutrition (SCAN) and heart rate monitoring. | Mean heart rates > 140bpm was considered MVPA. | Heart rate monitored physical activity was 4.2, 4.2 and 3.6 min/h for the 3 years, respectively. If we are to project daily activity levels, based on 12 h of awake time for the child, MVPA is postulated at 50.4 min for year 1 and 2 and 43.2 min per day for year 3 | No |
| Jago et al. (2005b) | 149 American participants (mean age 4 years) in year 1, with 147 and 138 for years 2 and 3, Boys = 73, Girls = 76 | Heart rate monitoring and CARS | The number of minutes above >140 beats were interpreted as minutes engaged in MVPA | Significant decreases in physical activity were present across the years. Heart rate monitor showed an average of 4.3, 4.1 and 3.5 min of MVPA and the CARS observation yielded 7.6, 5.3 and 5.8 min per hour for the 3 years, respectively | Yes |
| Janz et al. (2002) | 467 healthy American 4–6-year-old children, Boys = 217, Girls = 250 | CSA accelerometer | Minutes of MVPA $\geq$ 615 and vigorous physical activity $\geq$ 2972 counts. Used the Surgeon General's Report on Physical Activity and Health, which recommends at least 30 min of daily moderate physical activity | Boys had greater level of total physical activity than girls (774 cpm vs. 703 cpm). They also engaged in more MVPA and more vigorous physical activity than did girls, 277 min/day vs. 263 min/day). All of the children in this study appeared to reach 30 min of daily moderate physical activity | Yes |
| Janz et al. (2001) | 368 healthy American 4- to 6-year old children, Boys = 179, Girls = 189 | Parental report and the CSA accelerometer | Vigorous physical activity was $\geq$ 2972 movement counts | Boys had greater physical activity levels than did girls (766 cts/min compared to 701 cts/min) and boys engaged in more vigorous activity than did girls (32 min/day vs. 24 min/day) | No |
| Kain & Andrade, 1999 | 237 obese and 449 non-obese, low income Chilean 4 year olds, Boys = 329, Girls = 357 | One-day recall of usual daily activities on a weekday | Moderate activity was considered 1.8–3 METs intense was >3.0 | Intense activities were performed only 2 h by boys and 1.1 h by girls. Moderate activities were performed 3 h by boys and 3.6 h in girls | Yes |
| Kelly et al. (2006) | 339 kids, mean age 4.2 years, representative of Glasgow | Accelerometer | | Mean time spent in MVPA = 3% (0–13). This translates into 22 min per day | No |
| Kelly et al. (2006) | 78 preschoolers mean age 5.6 years from Glasgow, Boys = 38, Girls = 40 | Accelerometer | Moderate vigorous physical activity (MVPA) was categorized as observed time >3200 counts per minute | Mean time spent in MVPA = 3 (1–9). This translates into 22 min per day | No |

| | | | | | |
|---|---|---|---|---|---|
| Klesges et al. (1986) | 30 American children, aged 22–46 months, Boys = 15, Girls = 15 | FATS observation system | | Boys were more active than girls. Children spend 65% of their time in moderate activity | Yes |
| Logan et al. (2000) | 20 preschool aged children, from Glasgow, Scotland, Boys = 10, Girls = 10 | The Polar Vantage XL Heart Rate Monitor | The heart rate indices used to describe habitual physical activity were amount of time >50% above resting heart rate (RHR) (PAHR-50), % of time >25% above resting heart rate (PAHR-25) | Mean PAHR-25 = 64%, mean PAHR-50 = 22% | Yes |
| McKee et al. (2005) | 30, 3 and 4 year-old children from the UK, Boys = 13, Girls = 17 | A uniaxial pedometer, and CARS | | Boys were more active than girls. The mean score for boys and girls on the Digiwalker were 66.8 and 47.4 steps per 3 min, respectively. The mean CARS score for boys was 1.8 while girls was 1.6. 0.2% of observed time had a CARS rating of above 4.0 (medium or moderate translocation) | No |
| McKenzie et al., 1992 | 351 American children, aged 4 years old, Boys = 182, Girls = 169 | Direct observation, SCAN | | Children spent an average of 18.9% at home vs. 42.4% during recess in MVPA. That translates into 26 min of activity during two 30 min recesses and 22 min during 120 min observation at home. However, there is ample time for additional activity | Yes |
| Metallinos-Katsaras, Freedson, Fulton, & Sherry (2007) | 56 American preschool-aged children, Boys = 26, Girls = 30 | CSA accelerometer. | Moderate = 615–2971 cpm Vigorous = 2972–5331, Very vigorous = > 5331, Active time = moderate + vigorous + very vigorous | Children engaged in 272.2 min/day of active time. Girls engaged in slightly less activity than boys, 260.9 vs. 285.2 min/day ($p = 0.13$) | Yes |
| Montgomery et al., 2004 | 104 preschool aged children (mean age 5.3 years) from Glasgow, Boys = 52, Girls = 52 | The Doubly Labeled Water method and the CSA accelerometer | | Physical activity level was 1.66 for boys and 1.48 for girls which was a significant difference ($p = 0.0001$). Preschoolers MVPA occurred for 15% of observed time, which translates into 108 min | Yes |
| Noland, Danner, DeWalt, McFadden, & Kotchen (1990) | 21 American preschoolers, Boys = 11, Girls = 10 | Daycare and home observation | 1 represents low activity and 5 represents high activity | Children engaged in 10.8% of time in level 4 or greater intensity. This translates into approximately 77 min | Yes |
| Oja and Jurimae (2002) | 294, preschool children from Tartu, Estonia, Boys = 161, Girls = 133 | A parents and teacher physical activity questionnaire | | Girls were more active than boys. Mean MVPA for all children was 47.1 min/day, with boys engaging in 37.9 min/day vs. 56.4 min/day for girls. Children spent significantly more time in outdoor MVPA (78.5) on the weekends in comparison with indoor activity (43.7). Also, children only spent 42.8 min/day in MVPA outdoor during the week | No |
| Pate et al. (2004) | 247 American children, aged 3–5 years from nine preschools, Boys = 115, Girls = 132 | Actigraph uniaxial accelerometer | > 3.0 METs was categorized as MVPA | Children spent an average of 7.7 min per hour in MVPA, with slightly higher, yet significant levels in boys than girls (7.8 vs. 7.0). Based on a 12-h day, projected MVPA would be 92.4 min per day | Yes |
| Pate et al. (1996) | 47 American children, aged 3 and 4, Boys = 25, Girls = 22 | The Quantum XL Telemetry heart rate monitor | Activity was quantified as the percentage of time the heart rate was 50% above their individual heart rate | The physical activity level ranged from 12 to 15% during the 3 years of study | Yes |
| Poest et al. (1989) | 514 children and 46 daycare teachers participated, Boys = 269, Girls = 245 | A parent and teacher survey | | Preschool children in this study spent an average of 25.4 h per week in large motor activity (3.6 h per day). Boys spent significantly more time in activities than girls | Yes |

Table 1 (*Continued*)

| Author, date | Participants | Assessment method | Physical activity guidelines used to define moderate to vigorous physical activity | Physical activity level | Majority of participants sufficiently active (based on the NASPE guidelines) |
|---|---|---|---|---|---|
| Reilly et al. (2006) | 36 nurseries in Glasgow and 545 children (mean age 4.2 years), Boys = 273, Girls = 272 | The CSA accelerometer. | MVPA was classified as > 3200 counts per minute and sedentary behavior was <1100 counts per minute | Baseline mean of physical activity for the intervention group was 732 counts per minute and 809 counts per minute for those in the control group. The median percent of monitored time in MVPA was 2.6% and 3.0% per day | No |
| Reilly et al. (2004) | Children from Glasgow at age 3 ($n$ = 78) and then a follow-up at age 5 ($n$ = 72), Boys = 40, Girls = 38 | The doubly labeled water method and the CSA accelerometer | Children should accumulate at least 60 min of MVPA per day | The mean physical activity level for children was 1.61 and these children had a mean of 818 accelerometry counts per minute. At age 3, only 2% of time was spent in MVPA. At age 5, 4% of time was spent in MVPA. Children spent typically only 20-25 min per day in MVPA. By age 5, boys were more active than girls | No |
| Sääkslahti et al. (2004) | 228 preschoolers (mean age 4.4 years) from Turku Finland, Boys = 118, Girls = 110 | Physical activity diary completed twice yearly by parents | | In the spring, very active indoor (running, jumping, etc.) play was 1.48, 1.11 and 1.18 h/weekend and very active outdoor play was 1.85, 2.50 and 2.15 h/weekend for year 1, 2 and 3, respectively. In the fall, very active indoor play was 0.88, 0.88 and 0.78 h/weekend and very active outdoor play was 2.15, 1.99 and 2.78 h/weekend for year 1, 2 and 3 | Yes |
| Sallis et al. (1988) | 33, 3–5-year-old American children, Boys = 13, Girls = 20 | A direct observation technique called FATS | Moderate activity was defined as all levels of crawling, extreme sitting, extreme standing, and mild and moderate climbing and walking | These preschool children spent 60% of the observed time in sedentary activities. 31% of the observed intervals were spent in moderate activity | Yes |
| Telford et al. (2005) | 296 children aged 5 and 6 from Melbourne Australia, Boys = 151, Girls = 145 | MTI accelerometer | The UK physical activity recommendations state that children should participate in at least 60 min of moderate vigorous physical activity (MVPA) per day | Boys engaged in physical activity more frequently than girls. Almost all children (96-99%) met the MVPA physical activity guidelines for children. Most of the 6 year olds accumulated at least 120 min of MVPA per day | Yes |
| Trost et al. (2003) | 245 American over-weight (OW) and non-overweight (NOW) children, Boys = 118, Girls = 127 | OSRAP and Manufacturing Technologies Inc. 7164 uniaxial accelerometer | | The mean activity rating for children was 2.50 for OW girls and 2.49 for NOW girls; 2.40 for OW boys and 2.6 for NOW boys. The percent of time spent in MVPA was 42.2 for OW girls and 41.6 for NOW girls; 39 for OW boys compared to 47.6 for NOW boys | Yes |
| Vasquez, Salazar, Andrade, Vasquez, & Diaz (2006) | 24, 3–5-year-old obese children in Santiago City, Chile, Boys = 12, Girls = 12 | A doubly labeled water and a triaxial movement sensor (TRITRAC-R3D) | NASPE guidelines | Only 22 min/day during the week and 32 min/day on the weekend was spent in MVPA, PAL boys = 1.61, PAL girls = 1.55 | No |

The CSA/MTI/Actigraph is one accelerometer, MVPA = moderate vigorous physical activity, cpm = counts per minute, sufficiently active was achieved if more than 50% of participants engaged in 60 min or more of daily MVPA.

## 3. Results/discussion

A total of 39 primary studies (published 1986–2007) representing a total of 10,316 participants (5236 male and 5080 female) from seven countries (United States, Scotland, Finland, Australia, Chile, Estonia, Belgium), were included in this study. The sample size of these studies ranged from 12 preschoolers to 3141 preschoolers, with a mean sample size of 264. Physical activity levels were measured using accelerometers in 19 of the studies (49%), while direct observation was used in 13 of the studies (33%). Self-reports ($n = 8$; 21%), heart rate monitors ($n = 6$; 15%), pedometers ($n = 5$; 13%), and the doubly labeled water technique ($n = 4$; 10%) were used less frequently. The doubly labeled water technique is an isotope-based measurement of energy expenditure completed by assessing the divergence in enrichments of 2 isotopic labels in body water—1 of hydrogen and 1 of oxygen. A number of studies used more than one assessment method ($n = 14$; 36%). Physical activity observation and evaluation were typically conducted at the daycare ($n = 3$) or in the child's home ($n = 10$). Individual components of each study are defined and delineated in Table 1.

### 3.1. Prevalence of physical activity among preschoolers

Participants in each study were identified as sufficiently active if the mean (i.e., more than 50% of participants) engaged in 60 min of MVPA. Given that in many cases researchers did not provide the raw number of participants who engaged in 60 min of MVPA, the mean physical activity level for the population had to be used. Therefore, some participants in the study may have been sufficiently active even if the study was identified as not sufficiently active. In some cases where researchers did not use the NASPE guidelines, extrapolations based on the mean activity level were made to calculate total activity level.

Nearly half of the studies included in this review reported physical activity levels of less than 60 min/day, and consequently, this results in those preschoolers being insufficiently active according to the NASPE guideline. Twenty-one of the studies reviewed, or 54%, reported that children of this age group were moderately physically active for a minimum of 60 min/day. Therefore, 46% of studies reported that preschoolers did not meet the recommended guidelines for physical activity. For instance, Dowda et al. found that 27% of children's outdoor activity was spent in MVPA (Dowda et al., 2004). This means children attending daycares that offer two, 1 h outdoor playtimes per day, engaged in approximately 32 min of MVPA during this timeframe. Although substantial time remains during the day for children to accumulate an additional 28 min, physical activity in preschoolers has been highly correlated with outdoor playtime (Burdette et al., 2004; Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008; Sallis et al., 1993). Similarly, Fisher and colleagues (2005b) used accelerometers to evaluate physical activity behavior in 209 preschoolers and found that children engaged in only 2.7, 3.8, 4.1 and 2.1% of their day in physical activity during spring, summer, fall and winter, respectively. Based on a 12-h day, this translates into only a half an hour of activity. Even Oja and Jurimae (2002) who used a self-report questionnaire (which tends to provide overestimations of actual behavior; Sallis et al., 1996) found that moderate or vigorous physical activity only occurred for an average of 47 min/day.

### 3.2. Sex differences

One clear finding from this review is that male preschoolers are more active than female preschoolers (Hands, Parker, & Larkin, 2006; Janz et al., 2001; Klesges, Malott, Boschee, & Weber, 1986; McKee, Boreham, Murphy, & Nevill, 2005; Montgomery et al., 2004; Moore, Nguyen, Rothman, Cupples, & Ellison, 1995; Poest et al., 1989; Reilly et al., 2004; Telford, Salmon, Timperio, & Crawford, 2005). Specifically, Montgomery and colleagues (2004), using the doubly labeled water technique and accelerometers, recorded a physical activity level (total energy expenditure/predicted resting energy expenditure) of 1.66 for boys and 1.48 for girls which was a significant difference ($p = 0.0001$). Furthermore, Pate, Pfeiffer, Trost, Ziegler, and Dowda (2004) reported 7.8 versus 7.0 min/h of moderate physical activity for boys and girls, respectively. The variation in activity based on gender was so evident in the study conducted by Goran et al. that male preschoolers met the NASPE guidelines, whereas female preschoolers did not (Goran, Gower, Nagy, & Johnson, 1998). Of the 18 articles that reported on the sex differences in behavior, 16 found that male preschoolers were more active than females; in fact, only two studies reported the contrary (89%). One of these studies was conducted in Tartu Estonia, where researchers attributed this finding to the female involvement in dance and aerobic lessons as far greater than their male counterparts (Oja & Jurimae, 2002). This key finding highlights the need for effective interventions and programming to promote healthy levels of activity in young girls.

### 3.3. Measurement differences

Although a possible hypothesis prior to the start of this study might have been that physical activity level would be higher in studies which used proxy report measures, this finding was not confirmed. No differences in physical activity level based on measurement methods appeared in these findings. Although prevalence rates for physical activity were expected to differ with the measurement tool used, no differences were actually found in this review. In fact, those children who were found to be meeting the physical activity guidelines were measured using proxy-report (Burdette & Whitaker, 2005a; Burdette et al., 2004; Kain & Andrade, 1999; Poest et al., 1989), heart rate monitors (Benham-Deal, 2005; Jago, Baranowski, Thompson,

Baranowski, & Greaves, 2005b; Logan, Reilly, Grant, & Paton, 2000; Pate et al., 1996), accelerometers (Hands et al., 2006; Pate et al., 2004; Telford et al., 2005; Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003), pedometer (Hands et al., 2006), direct observation (Klesges et al., 1986; McKenzie, Sallis, Nader, Broyes, & Nelson, 1992; Sallis et al., 1988), and the doubly labeled water technique (Franks et al., 2005; Montgomery et al., 2004). Given the variation in measurement tool used, the findings from this review are not just overestimations on the part of parents, teachers, or daycare providers (i.e., from proxy-report).

The purpose of this systematic review was to assess the physical activity levels of preschool-aged children. A total of 39 studies were included, measuring physical activity levels using varying methods and techniques. Of these studies, 21 reported that children were active at the level necessary to meet the recent preschooler physical activity guidelines (54%). Although it is reassuring that just over half of these studies are reporting preschoolers as sufficiently active in accordance with the NASPE guidelines, the remaining half are not active enough for health benefits (based on the NASPE's current standards). Moreover, this study assessed physical activity levels using a very conservative guideline for sufficient activity, and in fact, ideally, preschoolers should be engaging in a number of hours of structured and unstructured physical activity. If this systematic review had considered sufficient activity as 2 or more hours of physical activity per day, the number of studies documenting sufficient activity would decrease to 23%. Furthermore, researchers have shown that children's activity levels are "not only low in intensity but also not sustained over extended periods of time" (Hoos, Gerver, Kester, & Westerterp, 2003, p. 608). While this is disconcerting, it is important to note that short, low intensity bouts of physical activity is developmentally and age appropriate. Not only do preschoolers lack the attention spans to sustain longer durations of activity, they also lack the motor development for continuous bouts.

A chief finding from this review was that even in children as young as the preschool years (aged 2–6) a discrepancy in activity between genders is evident. Numerous researchers have confirmed this notion among preschoolers and this trend appears stable well into adolescence (Goran et al., 1998; Trost et al., 2002). In fact, physical activity rates in females have been shown to decrease 50% between 6.5 and 9.5 years of age (Goran et al., 1998). Health promotion programs targeting physical activity among females seem necessary given their substantially lower levels of activity during childhood and adolescence.

It is important to note that not all researchers used the NASPE guidelines to operationally define physical activity (only four researchers used this guideline). A substantial portion of the studies included were conducted prior to the release of these recommendations. As a result, some researchers concluded that the children in their study were sufficiently active based on other standards used. Due to the variation in guidelines used by researchers and the NASPE recommendation used for this review, varying findings were apparent. Furthermore, the new guidelines focus on incorporating unstructured activity, in many cases, as a form of play, which makes evaluating the behavior even more challenging. Therefore, the need for a uniform assessment method for physical activity levels, according to the recent NASPE prescription is necessary as this was a major limitation of the current review.

An additional limitation of the present review was that in many cases raw data on the physical activity levels was not provided and therefore only the percent of participants in each study who met the physical activity guidelines could be considered. As a result, participants were identified as sufficiently active if the mean physical activity level was greater than 60 min/day. Consequently, a substantial number of preschoolers were deemed sufficiently active, when in fact; their physical activity level was below the mean, and therefore might have been inaccurately represented. But, given the difficulty in connecting a number of studies which used a variety of measurement tools, this was the only appropriate method for contrasting activity among this age group.

The evaluation of physical activity levels is merely a reflection of the validity of the techniques used to gather data (Timmons, 2005). Previous researchers have sacrificed the accuracy of their measure to conduct their research in a low-cost manner. In contrast, those who have used direct observation or the doubly labeled water technique have incurred high costs, which can only be done in small groups. Therefore, consideration needs to be given to measurement technique as this is a key limitation of all studies assessing physical activity in this population.

### *3.4. Measurement considerations*

Measuring physical activity levels in children is a challenging proposition, especially preschool children (Penpraze et al., 2006). Children's activity patterns (bouts of physical activity with intermittent rest periods) coupled with their inability to cognitively recall their activity level makes documenting physical activity behaviors difficult (Pate, 1993; Penpraze et al., 2006). Accurately recording physical activity levels among preschoolers is important for not only comparing and tracking changes in activity behavior but also to endorse programming aimed at those populations who are not engaging in activity at the level necessary for health gains. However, we lack precise and well-validated tools to assess physical activity (Trost, Ward, McGraw, & Pate, 1999). A number of measurement tools were used in this review including proxy-report, accelerometer, pedometer, heart rate monitor, direct observation, and the doubly labeled water technique, all of which offer different strengths and limitations.

The ease of administration and use and the low cost of self-report make them the most commonly used in population-based studies (proxy report in the case of young children; Pfeiffer, McIver, Dowda, & Almeida, 2006; Trost et al., 1999). Notwithstanding, proxy-reports can be challenging when assessing young children's physical activity given the need for parents or daycare leaders to complete the tool on the children's behavior due to the children's inability to do so themselves. Moreover, many researchers believe that proxy-reports provide gross estimations of activity, at best (Bates, 2006; Pfeiffer et al., 2006).

Although objective measures (such as accelerometers) have become frequently used and deemed an ideal way to measure activity, it is necessary to acknowledge that these tools have limitations. Firstly, accelerometers are expensive to acquire, not readily available and entail technical expertise (Cardon & De Bourdeaudhuij, 2007). Additionally, accelerometers lack the ability to correctly appraise "energy expenditure during non-weight-bearing activities" and can pose problematic when assessing intricate movements that are common during free play (Freedson, 1991; Trost et al., 1996, 1999). Moreover, researchers believe that seven days of monitoring is necessary to gain a precise estimate of activity, which further increases logistical problems as well as cost (Penpraze et al., 2006). The existence of numerous intensity cut-off values (for researchers to convert accelerometer data into minutes of MVPA), and given the numerous accelerometers available, makes quantifying, understanding and tracking physical activity challenging. Specifically, the lack of a standardized approach makes comparing activity behaviors across studies difficult (Trost, 2007). Lastly, accelerometers provide information on preschoolers' intensity, frequency and duration of physical activity; however, provides no information on the type of activity or the context in which it occurs (Trost, 2007). Despite these limitations, accelerometers offer an accurate measure of physical activity in a viable and reasonable manner.

Pedometers have been identified as an appropriate tool for large-scale studies given the low cost and feasibility, in addition to the accuracy and reliability among children (Cardon & De Bourdeaudhuij, 2007; McKee et al., 2005). However, pedometers have been recognized to record "less than the actual number of steps during slow walking" and as a result smaller or younger children's step counts might be an underestimation (Cardon & De Bourdeaudhuij, 2007, p. 206).

Direct observation and doubly labeled water technique have also been used to objectively gauge activity in preschoolers. However, these two measures are not used as often given the high cost and the invasiveness of the measure. All tools considered offer differing levels of accuracy, but also varying degrees of appropriateness and feasibility of use. Given the numerous different physical activity measures, it makes it challenging to compare activities of preschoolers across studies. Moreover, the preference for physical activity measurement tool depends on the nature and goal of the study; each tool has advantages and disadvantages and therefore, a "trade-off between practicality and accuracy (occurs) when it comes to selecting a physical activity measurement tool" (Trost, 2007, p. 314).

In addition to the difficulties in measuring physical activity levels, it can be challenging to compare physical activity prevalence rates across studies that have utilized different measures and varying scoring procedures (Sarkin, Nicholas, Sallis, & Calfas, 1998). For example, those studies using the doubly labeled water technique only do not provide information about the amount of time children were engaged in activity. Rather, their outcome measure offers a physical activity level (PAL; which is equal to total energy expended divided by basal metabolic rate). Therefore, it is not plausible to make inferences as to whether they are accumulating the recommended 60 min of activity.

### 3.5. *Daycare facilities*

Many parents now work outside the home. In particular, the Canadian Fitness and Lifestyle Research Institute (2005) reported that approximately half of preschool-aged children attend daycare. Preschool and daycare centres may provide appropriate venues to implement physical activity interventions (Burdette & Whitaker, 2005b; Finn et al., 2002; Reilly et al., 2006; Timmons, 2005). Specifically, Eastman denotes that "early childhood educators are in a unique position to support and encourage an active lifestyle among very young children" (Eastman, 1997, p. 161). These can take the form of educational programs for parents related to physical activity, or changes to their daily programming to foster more appropriate levels of physical activity (Ogden et al., 1997). Specifically, childhood professionals should focus on encouraging gross motor activity during outdoor playtime and support both movement and sedentary playing during indoor hours. A substantial number of studies assessed physical activity at the preschool or daycare ($n = 16$), which further highlights the appropriateness of targeting preschoolers through this venue. In fact, the daycare facility has been identified as the strongest determinant of physical activity and actually accounted for nearly 50% of the variation in activity during the daycare hours among Finn and colleagues sample (Finn et al., 2002). Recent progress to improve the policies enforced in support of physical activity among preschoolers during the daycare hours includes the New York City Health Code which took effect January 2007. This regulation requires group daycare facilities to ensure that the children in their care are engaging in 60 min of physical activity per day (American Medical Association, 2007). Additionally, daycare-based interventions have also showed promise. Specifically, Hannon and Brown (2008) revealed that the addition of activity-friendly equipment to outdoor preschool playgrounds was associated with decreased sedentary behaviors and an increase in light, moderate and vigorous physical activity among preschoolers. Hannon and Brown have highlighted that relatively minimal changes to the daycare facilities can have meaning implications for preschoolers' activity levels. Similarly, Dowda et al. (2004) found that children who attended daycares which afforded more field trips, and more college-educated teachers, had children who participated in more MVPA.

It is also important to acknowledge the role that parents and teachers play in providing support toward healthy levels of physical activity. Preschoolers are for the most part under the control of parents and therefore, it is important that parents recognize the importance of physical activity/play and foster this behavior in their child. Moreover, given that the preschool years range from 2 to 6 years, a number of preschoolers are enrolled in elementary school and therefore, the role of schools and teachers needs to be considered. Many of these children would be enrolled in Kindergarten, in which the curriculum offers a health and physical activity strand (Ministry of Education, 2006). These teachers need to be provided with the support and education necessary to encourage physical activity in their students.

## 4. Conclusions

Only 54% of preschoolers in this systematic review were sufficiently physically active and given that the obesity rates continue to rise in this age group (Ogden, Flegal, Carroll, & Johnson, 2002), health promotion efforts are necessary. NASPE suggests a minimum of 60 min of MVPA and up to several hours of unstructured play per day. For the purpose of this study, children were classified as adequately active if they engaged in at least the lower end of the NASPE recommended range. Therefore, it is possible that children need to be engaging in the higher end of the range, around 120 or 180 min of activity per day. The difference between the two would dramatically decrease the prevalence of children meeting the recommendations in this review.

This is the first study to document the physical activity levels of preschool-aged children in accordance with the NASPE physical activity guidelines. With a better understanding of the physical activity rates of preschoolers, interventions that promote and support physical activity in the lives of children, specifically preschoolers are necessary. If researchers' assumption that early activity is imperative for long-term health benefits is correct, then the long-term health of preschoolers could result in drastic increases in health care costs and rises in obesity levels, as nearly half of preschool-aged children are not sufficiently active, and this rate will continue to increase with age (Gordon-Larsen, Nelson, & Popkin, 2004).

### *4.1. Future research*

Future research focused on documenting physical activity levels among this population need to utilize objective tools (i.e., accelerometers) so that more accurate assessments of behaviors can be captured. Given the variation in assessment tools and consequently the difficulty in comparing activity levels across groups, using the same objective assessment tool might allow for a greater understanding of the activity levels of preschoolers from differing daycares, cities, and countries. Continued research is necessary to understand the high correlation between physical activity among preschoolers and outdoor playtime. By highlighting this association, it is important that researchers consider the available equipment, playgrounds, play space and parent or daycare leader encouragement as possible variables in this equation. Additionally, research identifying the correlates of preschoolers' physical activity might allow for more research-informed health promotion programs. Upon completion of this necessary research, the implementation of physical activity-based health promotion programs among preschoolers, especially females, both within daycare facilities and the community might serve as an effective means of encouraging activity levels in accordance with NASPE guidelines. Future research might also include: assessing whether female preschoolers are sufficiently active to achieve the health benefits associated with moderate level physical activity; the reasons for the lack of physical activity among females; and creating female-specific health promotion programs to target this specific population.

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