Adapted Physical Activity Quarterly, 2009, 26, 307-320

Do Children With Down Syndrome Perform Sufficient Physical Activity to Maintain Good Health? A Pilot Study

Nora Shields, Karen J. Dodd, and Casey Abblitt
La Trobe University

Our pilot study investigated if children with Down syndrome engaged in the recommended 60 min of moderate to vigorous physical activity (MVPA) every day. Twenty-three children with Down syndrome (7 girls, 16 boys; mean age 11.7 years, *SD* = 3.1) wore a triaxial accelerometer for 7 consecutive days to measure their activity levels. The average daily MVPA undertaken was 104.5 min (*SD* = 35.3 min). Only 8 of 19 children (42.1%) completed at least 60 min of MVPA each day. Lower amounts of activity were associated with older children ($r = -.67$, $p < .01$). Parents, teachers, and health professionals need to encourage children with Down syndrome to take part in more frequent MVPA.

Engagement in regular physical activity by children with Down syndrome is essential for their health, and not performing the recommended amount of activity may contribute to their increased risk of cardiovascular disease (Pitetti, Rimmer, & Fernhall, 1993) and obesity (Rubin, Rimmer, Chicoine, Braddock, & McGuire, 1998). Down syndrome is the most common genetic cause of intellectual disability and is associated with congenital heart defects, muscle hypotonicity, joint hypermobility, low cardiovascular fitness, and decreased muscle strength (Croce, Pitetti, Horvat, & Miller, 1996; Fernhall et al., 1996; Horvat, Pitetti, & Croce, 1997; Roizen & Patterson, 2003). These impairments may contribute to a delay in the acquisition of motor skills in children with Down syndrome and also to the development of atypical motor patterns (Mahoney, Robinson, & Fewell, 2001; Wang and Ju, 2002). Although children with Down syndrome develop skills in the typical sequence (albeit slower), their movement strategies tend to be less efficient (Mahoney et al., 2001), which in conjunction with their reduced exercise capacity may impede their participation in physical activity (Whitt-Glover, O'Neill, & Stettler, 2006). Considering the association of low levels of activity with obesity (Rowlands, Ingledew, & Eston, 2000) and that 45% of males and 56% of females with Down syndrome are overweight (Rubin et al., 1998), it is especially important for children with Down syndrome to adhere to the minimum recommended activity guidelines.

The authors are with the School of Physiotherapy at La Trobe University in Melbourne, Victoria Australia.

Physical activity enhances body composition (LeMura & Maziekas, 2002), skeletal health (Bradney et al., 1998; Morris, Naughton, Gibbs, Carlson, & Wark, 1997), and several aspects of psychological health including self-concept and self-esteem in children (Trost, 2005). International government agencies and research groups have published guidelines on the amount of physical activity children should undertake daily and many recommend children should participants in at least 60 min of moderate to vigorous physical activity (MVPA) each day (Australian Government Department of Health and Ageing, 2007; Strong et al., 2005). In addition, it is recommended that children perform 20 min of continuous vigorous activity on at least 3 days each week to improve cardiovascular health (Strong et al., 2005).

A recent review identified only 19 studies that have investigated the level of physical activity undertaken by children with intellectual disability (Frey, Stanish, & Temple, 2008). Of these, only 4 studies investigated physical activity in children with Down syndrome (Luke, Roizen, Sutton, & Schoeller, 1994; Jobling & Cuskelly, 2006; Sharav & Bowman, 1992; Whitt-Glover et al., 2006). Two studies used qualitative methods (Jobling & Cuskelly, 2006; Sharav & Bowman, 1992); one reported parents of 30 children with Down syndrome aged 2–11 years considered these children to be less active ($t = 2.9$, $p < .01$) than their siblings without Down syndrome of comparable age (Sharav & Bowman, 1992), and in the second study parents reported their family engaged in some weekly exercise (Jobling & Cuskelly, 2006). Two studies used quantitative methods (Luke et al. 1994; Whitt-Glover et al., 2006). One study (Whitt-Glover et al., 2006) used accelerometers to determine the amount of physical activity 28 children with Down syndrome (mean age 6.6, $SD = 2.1$ years) and 30 of their unaffected siblings (mean age = 7.7, $SD = 2.1$ years) performed over 7 days. No significant difference in the amount of moderate level activity was found (153.1 vs. 154.6 min per day), but the siblings without Down syndrome performed significantly more vigorous intensity activity (49.5 vs. 68.6 min per day; $p = .04$). It was also reported that although children with Down syndrome recorded more than 30 min of vigorous activity per day, this form of activity was intermittent, usually performed in short bouts ($M = 3.9$, $SD = 3.1$ min per bout; Whitt-Glover et al., 2006). A second study found no difference in energy expenditure measured using the doubly labeled water method between 12 children with Down syndrome and 10 children with typical development matched for age, gender, and body mass index (Luke et al., 1994).

It is important to establish good activity habits early in life as this may be an important factor for continued healthy activity patterns in adulthood. Activity levels in adolescence have been found to be a significant predictor of physical activity during adulthood (Telama et al., 2005; Glenmark, Hedberg, & Jansson, 1994; Stephens, Jacobs, & White, 1985), and there is some evidence that children with intellectual disability become less active as they get older (Stephens et al., 1985). There are currently no data on the amount of physical activity in children with Down syndrome aged 11 years and over. This information is necessary to help isolate the reasons for low fitness in children with Down syndrome and to assist health professionals involved in disease prevention to develop strategies that enhance participation in activity by children with Down syndrome.

Accordingly the aims of this pilot study were to measure the usual amount and intensity of physical activity children with Down syndrome complete over 7 days to determine if they satisfied published guidelines on the amount of physical activity children should undertake daily. Specifically, we wanted to determine if they performed 60 min of MVPA each day and if they performed 20 min of continuous vigorous activity at least three times a week.

Method

Participants

Children with Down syndrome aged 7–17 years were invited to participate in this study through a flyer inserted into the quarterly magazine sent out by a state based Down syndrome association. This age range was chosen as good activity habits established in school aged children may be an important factor for continued healthy activity patterns in adulthood. The advertising flyer was sent to 267 people, although it was not possible to know how many of these were eligible for inclusion in the study. Interested families were asked to contact the researchers directly. Participants were excluded if they had an acute injury or illness (such as an acute ankle sprain) that might alter their normal levels of activity or if they had a concurrent medical condition in addition to Down syndrome (such as cerebral palsy) which might have a negative impact on their level of physical activity.

Twenty six children with Down syndrome volunteered to participate but three of these did not meet the inclusion criteria. One child was scheduled for surgery to resolve an uncorrected heart abnormality, another child had a concurrent diagnosis of autism, and one child would not tolerate wearing an accelerometer. Twenty-three children (7 girls, 16 boys) of mean age 11.7 years (SD = 3.1 years), mean height of 138.4cm (SD = 17.3cm), mean weight of 43.8kg (SD = 17.1kg), and an average BMI of 22.1 (SD = 6.1) participated in the study (see Table 1). Twenty-two children had a diagnosis of Trisomy 21 and one child of mosaic Down syndrome. The participants level of intellectual disabilities was described by their parents perception as mild (n = 9), mild to moderate (n = 3), or moderate (n = 11).

Equipment

Physical activity was measured over 7 consecutive days using an RT3 accelerometer. Accelerometry was chosen because (a) unlike heart rate monitoring, it cannot be influenced by emotional stress; (b) unlike pedometers, participants do not get visual feedback about the amount of activity they perform that could impact on their usual level of activity; and (c) noncompliance is easily quantified (Bjornson, 2005). A 7-day data collection period has been found to provide sufficient time to obtain a reliable estimate (r = 0.76–0.86) of normal activity in children and adolescents aged 6–17 years, as it allows for differences in activity levels across the day and between weekdays and weekends (Trost, Pate, Freedson, Sallis, & Taylor, 2000). A short logbook was also completed by the child's parents to report any problems that arose while their child was wearing the accelerometer and to indicate if their child did not wear the accelerometer for a period of time (e.g., during bathing or swimming).

Table 1 Individual Participant Daily Moderate or Vigorous Level Activity Data

DAY			Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Daily average	COV	Average Mon-Fri	Average Sat-Sun	Guidelines met?
ID	Sex	Age (yrs)												
1	F	7	152	171	165	147	168	220	203	175.1	15.3	160.6	211.5	yes
2	M	8	123	59	83	120	116	93	72	95.1	26.5	100.2	82.5	no
3	F	8	194	174	0	157	146	222	134	146.7	21.3	134.2	178.0	yes*
4	M	9	185	203	143	142	129	127	144	153.3	19.0	160.4	135.5	yes
5	M	10	154	145	195	89	136	168	142	147.0	22.1	143.8	155.0	yes
6	F	10	113	132	145	138	206	138	100	138.9	24.2	146.8	119.0	yes
7	M	11	99	66	85	85	66	94	154	92.7	32.2	80.2	124.0	yes
8	M	11	146	110	109	113	153	139	112	126.0	15.2	126.2	125.5	yes
9	M	11	93	14	52	103	15	0	17	42.0	88.6	55.4	8.5	no*
10	M	12	92	70	63	60	115	58	86	77.7	27.0	80.0	72.0	no
11	M	12	117	115	130	131	59	170	42	109.1	40.5	110.4	106.0	no
12	M	14	113	52	144	135	124	53	97	102.6	36.4	113.6	75.0	no
13	M	14	134	52	91	47	87	67	41	74.1	44.1	82.2	54.0	no
14	F	14	103	81	66	64	64	49	133	80.0	36.1	75.6	91.0	no
15	M	15	46	87	79	82	105	76	59	76.3	25.1	79.8	67.5	no
16	M	15	42	86	98	112	85	55	84	80.3	30.0	84.6	69.5	no
17	M	16	114	100	109	208	118	81	101	118.7	34.7	129.8	91.0	yes
18	F	16	81	110	137	45	76	10	53	73.1	57.7	89.8	31.5	no
19	F	17	70	36	74	118	117	58	61	76.3	40.2	83.0	59.5	no
Mean		12.1								104.5		107.2	97.7	

Key: ID, identification number; yrs, years; M, male; F, female; *, this participant only wore the accelerometer for 6 consecutive days (note: data collection did not always start on a Monday). COV = Coefficient of Variation.

Note. Level of activity is measured in number of minutes.

The RT3 accelerometer (see Figure 1) is a small, easy to use device that is worn on the user's waistband (Rowlands, Thomas, Eston, & Topping, 2004). It measures acceleration of the body via a piezoelectric crystal and an attached mass, mounted on a supporting base. When an acceleration force is applied to the accelerometer, the attached mass exerts force on the crystal, and the crystal generates an output that is equal to the acceleration force. This output is integrated over a 1-min time interval and converted into an activity count that represents how much activity was performed during that minute (Powell & Rowlands, 2004). The accelerometer was activated and data downloaded using computer software (Stay-Healthy Inc, Monrovia, CA). The RT3 has demonstrated good intermonitor reliability (r = 0.99; Powell, Jones, & Rowlands, 2003) and its output was strongly correlated with oxygen consumption values (SVO_2) in 19 boys (r = 0.87) and 15 men (r = 0.85), providing evidence of criterion validity (Rowlands et al., 2004).

Procedure

Ethical approval was obtained from the Faculty Human Ethics Committee at the University where the research took place. A researcher then met with the parents and their children to gain written informed consent and to demonstrate how to wear the accelerometer. The child's age, gender, height, weight, type of Down syndrome, and level of intellectual disability (described mild, moderate, or severe as perceived by their parents) were documented. The child was asked to wear the accelerometer for eight days (one day familiarization and seven days data collection) and was advised to remove it for water-based activities such as bathing and swimming. At the end of the data collection period, the accelerometer and diaries were returned to the researchers by post. All participants wore the accelerometer during school term time.

Figure 1 — RT3 accelerometer.

Data Analysis

Demographic data were analyzed descriptively. Body mass index (BMI) was calculated by dividing each child's weight in kilograms, by the child's height in meters squared (BMI = weight/height^2) and was then standardized for age and gender to the British reference population and converted to z scores (Cole, Bellizzi, Flegal, & Dietz, 2000; Cole, Freeman, & Preece, 1998). Data from the accelerometry were included if the child had worn the accelerometer for at least 6 of the 7 days of data collection. This time period has previously been found to provide acceptable estimates of daily participation in MVPA in children aged 7–17 Years ($r = 0.7$; Trost et al., 2000). A daily summary of how long each participant spent in MVPA was calculated and data were compared with the recommendations for children to complete at least 60 min of MVPA everyday, and at least 20 min of continuous vigorous activity at least 3 days a week. Moderate activity was classified as ≥ 970 activity counts per minute and vigorous physical activity was classified as ≥ 2333 activity counts per minute (Rowlands et al., 2004). These cut off points have been implemented in a previous research study of children aged 7–10 (Hussey, Bell, Bennett, O'Dwyer, & Gormley, 2007). Correlational analysis using Pearson's correlation coefficient was conducted to examine the association between the level of physical activity performed, age, and BMI score standardized for age and gender. A paired *t* test was used to determine if there was a significant difference between physical activity levels during weekdays and weekends. Coefficients of variation within participants and between participants during the 7-day data collection period were calculated by dividing the standard deviation of the activity score by the mean activity score. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 14.0. Pearson correlation coefficients were calculated to investigate the relationship between levels of physical activity, age, and BMI.

Results

Feasibility of Using Accelerometry in Children With Down Syndrome

Four children did not tolerate wearing the accelerometer over the 7-day data collection period. Nineteen of the 23 children wore the accelerometer for at least 6 days during the 7 day data collection period; two children prematurely ended the data collection period by mistake. The participants wore the accelerometers on average for 6.8 days ($SD = 0.4$ days) and for 742.4 min ($SD = 74.3$ min) per day. Although there is no standardized method for deciding what length of time an accelerometer needs to be worn in order for it to constitute a given day, the latter average time worn value is greater than that previously reported in the literature (Anderson, Hagstromer, & Yngve, 2005; Eiberg et al., 2005).

Comparison of Measured Activity Levels With Physical Activity Guidelines

The average amount of MVPA the participants completed each day was 104.5 min (*SD* = 35.3 min). The average daily amount of MVPA for younger children (ages 7–12 inclusive; *n* = 11) was 121.4 min (*SD* = 40.3 min), and for older children (ages 13–17 inclusive; *n* = 8) was 85.0 min (*SD* = 16.6 min; see Figure 2). The mean difference between the age groups was significant (36.4 min, 95% confidence interval 7.5–65.3 min, *p* = .02). The time each child spent in MVPA each day varied considerably; the coefficient of variation between participants was 33.7% and ranged within participants from 15.2% to 88.6%. Only 8 children (42.1%) undertook at least 60 min of MVPA each day for 7 days. Three children (15.8%) met the guidelines on 6 out of 7 days, 5 children (26.3%) met the guidelines on 5 days, 2 children (10.5%) met the guidelines on only 4 days, and one child (5.3%) met the guideline on only 2 days.

Vigorous Physical Activity

The average amount of vigorous activity the participants completed per day was 22.9 min (*SD* = 13.1 min). None of the children performed 20 min of continuous vigorous physical activity 3 times a week. Nine children performed more than 20 min of vigorous physical activity on 3 or more days; however, this activity did not occur in a single continuous bout.

Sedentary or Light Activity

The average amount of sedentary or light activity the participants completed per day was 640.7 min (*SD* = 83.1 min).

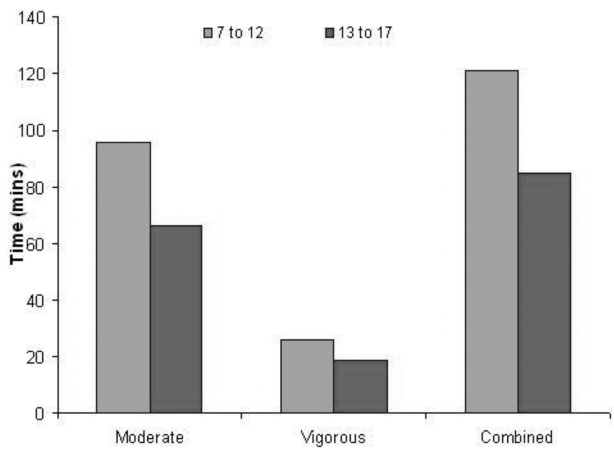

Figure 2 — Average time spent in moderate or vigorous physical activity per day according to age.

Duration of Activity Bouts

The children tended to perform intermittent bouts of both moderate and vigorous physical activity in preference to sustained periods of activity. On average, each bout of MVPA lasted approximately 2.8 min (*SD* = 0.6 min), while the average length of each vigorous physical activity bout was 2 min (*SD* = 0.6 min).

Factors Influencing Physical Activity Levels

Analysis found a significant inverse association between the level of physical activity in children with Down syndrome and age ($r = -.67$, $p < .01$); that is older children tended to record a lower level of physical activity. There was no significant association between activity levels and BMI standardized for age and gender ($r = -.3$, $p = 0.21$), and there was no significant difference between the mean activity levels between weekdays and weekends (paired t test = 1.34, $p = .2$).

Discussion

Implications of the Research Findings

Although the average daily MVPA undertaken by the participants was 104.5 min (*SD* = 35.3 min), only 8 of the 19 (42.1%) school aged children with Down syndrome that took part in this study performed at least 60 min of MVPA each day. Estimates from self-report or parent-report data suggest 15–25% of Australian children with typical development are insufficiently active (Booth, 2000; Spinks, Macpherson, Baina, & McClurec, 2007). An accelerometer based study found typically developing Australian children on average undertake 117 min (95% CI 112–121 min) of MVPA per day (Spinks, Macpherson, Baina, & McClurec, 2006). Two other accelerometer based studies have reported even higher levels of MVPA among children aged 10–12 years of between 141.1–157.3 min per day for boys and 119–126.7 min per day for girls (Hume, Salmon, & Ball, 2005; Cleland et al., 2008). These data should be considered in terms of the preliminary standards of physical activity for children aged 6–12 years related to healthy BMI that indicate boys and girls need to undertake 150 min and 120 min of MVPA per day respectively (Tudor-Locke et al., 2004). This suggests that many children with Down syndrome may not perform enough physical activity to maintain good health (Australian Government Department of Health and Ageing, 2007). This finding emphasizes the need for these children to increase the amount of moderate level physical activity they perform each day, as they are predisposed to diseases associated with inactivity including an increased risk of coronary artery disease and obesity in adulthood (Pate et al., 1995).

These data are the first examining the amount of physical activity undertaken by Australian children with Down syndrome, and they add to the very small amount of literature available in this area. Only one previous quantitative study has investigated the amount of physical activity undertaken by children with Down syndrome using accelerometry (Whitt-Glover et al., 2006). That study found that children with Down syndrome aged 3–10 years performed an average of 153.1 min of moderate physical activity per day (Whitt-Glover et al., 2006).

This is longer than the mean amount of moderate activity (104.4 min) performed by the participants in our study. The reasons for this difference are unknown; however, it is possible that the difference between the results could be because the children in our study were older than those in the previous study (mean age 11.7 years vs. 6.6 years), and it is known that the level of physical activity decreases with age in people with intellectual disability (Suzuki et al., 1991) and the general population (Stephens et al., 1985).

When compared with physical activity data of children with typical development from international studies (Troiano et al., 2008; Hussey et al., 2007), the participants in this study appear to be more active. It is possible that these data reflect the differences in activity levels of children from Europe, Australia and the U.S. Troiano et al. (2008) reported the amount of time spent in MVPA for American children aged 6–11 years was 95.4 min for boys and 75.2 min for girls, compared with Hussey et al., (2007), who found the Irish boys and girls of an equivalent age group (7–10 year olds) participated in 114.3 min and 96.6 min of daily MVPA, respectively. Differences in activity levels between children from different countries has been found in a study that compared step counts using pedometers for children from Sweden, the U.S. and Australia (Vincent, Pangrazi, Raustorp, Tomson, & Cuddihy, 2003). In that study, step counts for boys and girls were highest among Swedish population, followed by Australia and then the US.

The current participants self-selected for the study, therefore it is possible that some of the children with Down syndrome who volunteered for this pilot study were those who were extremely active, or that their parents believed activity was very important and so they were not representative of the wider population of children with Down syndrome. The levels of activity were very variable both between participants (33%) and within participants (15–88%). These analyses might suggest that since the participants and their families knew their activity levels were being monitored, they may have engaged in more MVPA than usual on particular days during the data collection period, and made it appear that the children were more active than they usually were.

Although a proportion of the children in this study had relatively high levels of MVPA, none of the children completed the 20 min of continuous vigorous activity on three days of the week recommended for improving cardiovascular fitness (Strong et al., 2005). The average amount of vigorous activity per day was 22.9 min (SD = 13.1 min); however, the average length of each vigorous physical activity bout was only 2 min (SD = 0.6 min). This is less than the average bout of activity for children with typical development who average 4.2 min of MVPA (Kalakanis, Goldfield, Paluch, & Epstein, 2001) and to the findings of Whitt-Glover et al. (2006), who found children with Down syndrome aged 3–10 years performed only short bouts of vigorous physical activity (M = 3.9, SD = 3.1 min). Performing sustained vigorous physical activity might be especially important for children with Down syndrome, due to their lower levels of cardiovascular fitness (Fernhall et al., 1996).

We found older children with Down syndrome tended to have lower levels of physical activity; this finding is consistent with published literature (Stephens et al., 1985; Suzuki et al., 1991). Establishing good physical activity habits during early childhood is an important factor for continued healthy activity patterns in adulthood as activity levels in adolescence are a significant predictor of physical activity during adulthood (Glenmark et al., 1994; Hallal, Victora, Azevedo, & Wells, 2006; Stephens et al., 1985; Telama et al. 2005). Literature also indicates there is a consistent long-term protective effect from physical activity during adolescence on bone health (Khan et al., 2000) and also that sedentary behavior during childhood as well as poor cardiovascular fitness in adolescence are associated with poor adult health outcomes (Hallal et al., 2006). Parents, teachers, and health professionals involved in the care of children with Down syndrome should therefore routinely incorporate strategies for increasing physical activity into their timetables.

Parents are probably best positioned to influence the lifestyle habits of their children and to implement changes in their child's activity behavior. Educating family members about the importance of regular activity to maintain good health and of sustained vigorous activity for improved cardiovascular health might help to increase the level of activity in children with Down syndrome. Families should be encouraged to incorporate activity into their daily routine where possible. For example, they could encourage walking or cycling to school instead of driving. Health professionals may also have a role to play by working with the family to devise strategies that are convenient to the family in terms of cost and time, are appropriate to the child's level of development, and are enjoyable for the child. Activities that can be pursued into adulthood have been recommended (Buckley, 2007), including swimming, dancing, cycling, and exercising at a local gym, as these activities can be completed by individuals of all levels of motor ability yet they would also include a social component which is a key facilitator of activity in people with Down syndrome (Mahy, 2007).

Recommendations for Future Research

Some difficulties arose from using accelerometers to measure the physical activity of children with Down syndrome, including an inability to tolerate wearing the accelerometer, losing the accelerometer, or stopping the data collection period prematurely. A previous study (Whitt-Glover et al., 2006) also reported compliance issues with 8 of 36 children with Down syndrome unable to wear an accelerometer. Although compact, the size of the RT3 unit may have been a factor as five children reported discomfort while wearing it. Future studies might consider using a smaller sized accelerometer or attaching the unit using an elastic belt or directly onto the skin may improve its wearability and make it less obtrusive. This would also reduce the risk of the accelerometer being dropped or lost and might allow the children to wear it with all types of clothing. For example, girls could to use it while wearing a dress.

Limitations of the Study

The method of recruitment of the participants is a potential limitation, as the participants self-selected and it is possible the families who volunteered for the study were those more positively predisposed toward physical activity, and this may account for the higher than anticipated mean daily activity levels. Accelerometers may underestimate the amount of activity performed as they are not sensitive to changes in the increased energy expenditure caused by static isometric exercise, walking or running up an incline, upper body movements, and carrying loads (Rowlands et al., 2004), and they also cannot be worn while swimming. Another limitation was that the 1-min interval used for sampling the data may have underestimated the amount of vigorous level activity (Nilsson, Ekelund, Yngve, & Sjostrom, 2002; Rowlands & Hughes, 2006). The only other sampling interval available on the RT3 accelerometer, however, is 1s, which allows for data to be collected for a maximum duration of 9 hr only, which was not sufficient for the current protocol. The amount of activity the children completed may also have been influenced by the parents knowing that their child's activity levels were being investigated and therefore they may have unwittingly encouraged their child to perform more physical activity than usual.

Finally, there have been no studies that validate the use of accelerometry for children with Down syndrome; this is a limitation of the current study, as the movement of people with Down syndrome tends to be less efficient and also they have a lower VO_{2peak} to those without disability, and so the cut off levels for moderate and vigorous activity may not be appropriate for this population. The cut off levels are those suggested by Rowlands et al. (2004) and are based on data from 19 boys and 15 men; it is possible that these cut offs are not appropriate for children and adolescents with Down syndrome. However, given the mean age of the current population and the mean age of the participants in the Rowlands et al. (2004) study are similar (9.5 years v 11.7 years), it is likely that the cut-off scores, if anything, underestimate the true cut-off point. These cut-off scores have also been used in previous literature (Hussey et al., 2007). Interpretation of activity scores is also limited as the cut off scores are also based on the concept of metabolic equivalents (MET); one MET is equal to the amount of energy expended by the body as a person sits quietly or approximately 3.5ml of oxygen uptake per kilogram of body weight per minute for an adult; however, using METs for children is controversial and recent evidence has demonstrated that even in adults the use of 3 and 6 METs to determine levels of activity is not always appropriate (Byrne, Hills, Hunter, Weinsier, & Schutz, 2005).

Conclusion

Almost 58% of children with Down syndrome did not perform the recommended amounts of physical activity to maintain good health and none performed the recommended level of continuous vigorous physical activity to enhance cardiovascular fitness. A significant inverse association was found between the amount of activity undertaken and age, with older children completing less activity. This information is important for parents, caregivers, teachers, and health professionals who work with children with Down syndrome and who are in a position to implement changes in their physical activity behavior.

References

Anderson, C.B., Hagstromer, M., & Yngve, A. (2005). Validation of the PDPAR as an adolescent diary: effect of accelerometer cut points. *Medicine and Science in Sports and Exercise, 37,* 1224–1230.

Australian Government Department of Health and Ageing. (2007). Australia's physical activity recommendations for children and young people. Retrieved 27th August 07, 2007, from http://www.health.gov.au/internet/wcms/Publishing.nsf/Content/health-pubhlth-strateg-active-recommend.htm

Bjornson, K.F. (2005). Physical activity monitoring in children and youths. *Pediatric Physical Therapy, 17,* 37–45.

Booth, M.L. (2000). What proportion of Australian children are sufficiently physically active? Recommendations for nutrition and physical activity for Australian children. *The Medical Journal of Australia, 173,* S1–S16.

Bradney, M., Pearce, G., Naughton, G., Sullivan, C., Bass, S., Beck, T., et al. (1998). Moderate exercise during growth in prepubertal boys: Changes in bone mass, size, volumetric density, and bone strength: A controlled prospective study. *Journal of Bone and Mineral Research, 13,* 1814–1821.

Buckley, S. (2007). Increasing opportunities for physical activity. *Down's Syndrome, Research and Practice, 12,* 18–19.

Byrne, N.M., Hills, A.P., Hunter, G.R., Weinsier, R.L., & Schutz, Y. (2005). Metabolic equivalent: One size does not fit all. *Journal of Applied Physiology, 99,* 1112–1119.

Cleland, V., Crawford, D., Baur, L.A., Hume, C., Timperio, A., & Salmon, J. (2008). A prospective examination of children's time spent outdoors, objectively measured physical activity and overweight. *International Journal of Obesity, 32,* 1685–1693.

Cole, T.J., Bellizzi, M.C., Flegal, K.M., & Dietz, W.H. (2000). Establishing a standard definition for child overweight and obesity worldwide: International survey. *British Medical Journal, 320,* 1240–1243.

Cole, T.J., Freeman, J.V., & Preece, M.A. (1998). British 1990 growth reference centiles for weight, height, body mass index and head circumference fitted by maximum penalized likelihood. *Statistics in Medicine, 17,* 407–429.

Croce, R.V., Pitetti, K.H., Horvat, M., & Miller, J. (1996). Peak torque, average power, and hamstrings/quadriceps ratios in nondisabled adults and adults with mental retardation. *Archives of Physical Medicine and Rehabilitation, 77,* 369–372.

Eiberg, S., Hasselstrom, H., Gronfeldt, V., Froberg, K., Svensson, J., & Andersen, L.B. (2005). Maximum oxygen uptake and objectively measured physical activity in Danish children 6-7 years of age: The Copenhagen school child intervention study. *British Journal of Sports Medicine, 39,* 725–730.

Fernhall, B., Pitetti, K.H., Rimmer, J.H., McCubbin, J.A., Rintala, P., Millar, A.L., et al. (1996). Cardiorespiratory capacity of individuals with mental retardation including Down syndrome. *Medicine and Science in Sports and Exercise, 28,* 366–371.

Frey, G., Stanish, H., & Temple, V. (2008). Physical activity of youth with intellectual disability: Review and research agenda. *Adapted Physical Activity Quarterly, 25,* 95–117.

Glenmark, B., Hedberg, G., & Jansson, E. (1994). Prediction of physical activity level in adulthood by physical characteristics, physical performance, and physical activity in adolescence: An 11-year follow-up study. *European Journal of Applied Physiology, 69,* 530–538.

Hallal, P.C., Victora, C.G., Azevedo, M.R., & Wells, J.C.K. (2006). Adolescent physical activity and health: A systematic review. *Sports Medicine, 36,* 1019–1030.

Horvat, M., Pitetti, K.H., & Croce, R. (1997). Isokinetic torque, average power, and flexion/extension ratios in nondisabled adults and adults with mental retardation. *The Journal of Orthopaedic and Sports Physical Therapy, 25,* 395–399.

Hume, C., Salmon, J., & Ball, K. (2005). Children's perception of their home and neighborhood environments, and their association with objectively measured physical activity: A qualitative and quantitative study. *Health Education Research, 20,* 1–13.

Hussey, J., Bell, C., Bennett, K., O'Dwyer, J., & Gormley, J. (2007). Relationship between the intensity of physical activity, inactivity, cardiorespiratory fitness and body composition in 7-10 year old Dublin children. *British Journal of Sports Medicine, 41,* 311–316.

Jobling, A., & Cuskelly, M. (2006). Young people with Down syndrome: a preliminary investigation of health knowledge and associated behaviours. *Journal of Intellectual & Developmental Disability, 31,* 210–218.

Kalakanis, L.E., Goldfield, G.S., Paluch, R.A., & Epstein, L.H. (2001). Parental activity as a determinant of activity level and patterns of activity in obese children. *Research Quarterly for Exercise and Sport, 72,* 202–209.

Khan, K., McKay, H.A., Haapasalo, H., Bennell, K.L., Forwood, M.R., Kannus, P., et al. (2000). Does childhood and adolescence provide a unique opportunity for exercise to strengthen the skeleton? *Journal of Science and Medicine in Sport, 3,* 150–164.

LeMura, L., & Maziekas, M. (2002). Factors that alter body fat, body mass and fat-free mass in pediatric obesity. *Medicine and Science in Sports and Exercise, 34,* 487–496.

Luke, A., Roizen, N., Sutton, M., & Schoeller, D. (1994). Energy expenditure in children with Down syndrome: Correcting metabolic rate for movement. *The Journal of Pediatrics, 125,* 829–838.

Mahoney, G., Robinson, C., & Fewell, R.R. (2001). The effects of early motor intervention on children with Down syndrome or cerebral palsy: A field-based study. *Journal of Developmental and Behavioral Pediatrics, 22,* 153–162.

Mahy, J. (2007). *Barriers and facilitators to exercise in adults with Down syndrome.* Unpublished thesis, La Trobe University, Melbourne, Australia.

Morris, F.L., Naughton, G.A., Gibbs, J.L., Carlson, J.S., & Wark, J.D. (1997). Prospective ten-month exercise intervention in premenarcheal girls: Positive effects on bone and lean mass. *Journal of Bone and Mineral Research, 12,* 1453–1462.

Nilsson, A., Ekelund, U., Yngve, A., & Sjostrom, M. (2002). Assessing physical activity among children with accelerometers using different time sampling intervals and placements. *Pediatric Exercise Science, 14,* 87–96.

Pate, R.R., Pratt, M., Blair, S.N., Haskell, W.L., Macera, C.A., Bouchard, C., et al. (1995). Physical activity and public health: A recommendation from the centers for disease control and prevention and the American College of Sports Medicine. *Journal of the American Medical Association, 273,* 402–407.

Pitetti, K.H., Rimmer, J.H., & Fernhall, B. (1993). Physical fitness and adults with mental retardation. An overview of current research and future directions. *Sports Medicine*, *16,* 23–56.

Powell, S.M., Jones, D.I., & Rowlands, A.V. (2003). Technical variability of the RT3 accelerometer. *Medicine and Science in Sports and Exercise, 35,* 1773–1778.

Powell, S.M., & Rowlands, A.V. (2004). Intermonitor variability of the RT3 accelerometer during typical physical activities. *Medicine and Science in Sports and Exercise, 36,* 324–330.

Roizen, N., & Patterson, D. (2003). Down's syndrome. *Lancet, 361,* 1281–1289.

Rowlands, A.V., & Hughes, D.R. (2006). Variability of physical activity patterns by type of day and season in 8-10-year-old boys. *Research Quarterly for Exercise and Sport, 77,* 391–395.

Rowlands, A.V., Ingledew, D.K., & Eston, R.G. (2000). The effect of physical activity measure on the relationship between body fatness and habitual physical activity in children: A meta-analysis. *Annals of Human Biology, 27,* 479–497.

Rowlands, A.V., Thomas, P.W., Eston, R.G., & Topping, R. (2004). Validation of the RT3 triaxial accelerometer for the assessment of physical activity. *Medicine and Science in Sports and Exercise, 36,* 518–524.

Rubin, S.S., Rimmer, J.H., Chicoine, B., Braddock, D., & McGuire, D.E. (1998). Overweight prevalence in persons with Down syndrome. *Mental Retardation, 36,* 175–181.

Sharav, T., & Bowman, T. (1992). Dietary practices, physical activity, and body-mass index in a selected population of Down syndrome children and their siblings. *Clinical Pediatrics, 31,* 341–344.

Spinks, A., Macpherson, A., Baina, C., & McClurec, R. (2006). Determinants of sufficient daily activity in Australian primary school children. *Journal of Paediatrics and Child Health, 42,* 674–679.

Spinks, A.B., Macpherson, A.K., Baina, C., & McClurec, R.J. (2007). Compliance with the Australian national physical activity guidelines for children: relationship to overweight status. *Journal of Science and Medicine in Sport, 10,* 156–163.

Stephens, T., Jacobs, D., & White, C. (1985). A descriptive epidemiology of leisure-time physical activity. *Public Health Report, 100,* 147–158.

Strong, W.B., Malina, R.M., Bumkie, C.J., Daniels, S.R., Dishman, R.K., Gutin, B., et al. (2005). Evidence based physical activity for school-age youth. *The Journal of Pediatrics, 146,* 732–737.

Suzuki, M., Saitoh, S., Tasaki, Y., Shimomura, Y., Makishima, R., & Hosoya, N. (1991). Nutritional status and daily physical activity of handicapped students in Tokyo metropolitan schools for deaf, blind, mentally retarded, and physically handicapped individuals. *The American Journal of Clinical Nutrition, 54,* 1101–1111.

Telama, R., Yang, X., Viikari, J., Välimäki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood: A 21-year tracking study. *American Journal of Preventive Medicine, 28,* 267–273.

Troiano, R., Berrigan, D., Dodd, K., Masse, L., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise, 40,* 181–188.

Trost, S.G. (2005). *Discussion paper for the development of recommendations for childrens and youths participation in health promoting physical activity*. Canberra: Australian Government Department of Health and Ageing.

Trost, S.G., Pate, R.R., Freedson, P.S., Sallis, J.F., & Taylor, W.C. (2000). Using objective physical activity measures with youth: How many days of monitoring are needed? *Medicine and Science in Sports and Exercise, 32,* 426–431.

Tudor-Locke, C., Pangrazi, R.P., Corbin, C.B., Rutherford, W.J., Vincent, S.D., Raustorpe, A., et al. (2004). BMI-referenced standards for recommended pedometer-determined steps/day in children. *Preventive Medicine, 38,* 857–864.

Vincent, S.D., Pangrazi, R.P., Raustorp, A., Tomson, L.M., & Cuddihy, T.F. (2003). Activity levels and body mass index of children in the United States, Sweden, and Australia. *Medicine and Science in Sports and Exercise, 35,* 1367–1373.

Wang, W., & Ju, Y. (2002). Promoting balance and jumping skills in children with Down syndrome. *Perceptual and Motor Skills, 94,* 443–448.

Whitt-Glover, M.C., O'Neill, K.L., & Stettler, N. (2006). Physical activity patterns in children with and without Down syndrome. *Pediatric Rehabilitation, 9,* 158–164.