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Original Article

Objectively measured physical activity levels of young children with congenital heart disease

Nicola Stone,[1] Joyce Obeid,[1] Rejane Dillenburg,[2] Jovana Milenkovic,[1] Maureen J. MacDonald,[3] Brian W. Timmons[1,3]

[1]*Child Health & Exercise Medicine Program;* [2]*Department of Pediatrics, Division of Cardiology;* [3]*Department of Kinesiology, McMaster University, Ontario, Canada*

Abstract Physical activity tends to be lower in school-age children with congenital heart disease than in healthy controls. To the best of our knowledge, objectively measured physical activity levels of preschool-age children with congenital heart disease have not been studied. *Methods:* A total of 10 children with either coarctation of the aorta (n = 6; age 3.8 ± 0.9) or tetralogy of Fallot (n = 4, age 4.3 ± 0.9) were recruited from the cardiology unit of McMaster Children's Hospital. Height (103.7 ± 8.2 cm) and weight (17.3 ± 2.7 kg) measurements were recorded, and physical activity was determined using accelerometry over 7 consecutive days. Patients were compared with age-, sex-, and season of data acquisition-matched controls. Parents completed a questionnaire regarding the child's physical activity and sedentary behaviours. *Results:* Patients spent on average 219.4 ± 39.9 minutes engaged in total physical activity per day at the following intensities: light, 147.5 ± 22.3; moderate, 44.0 ± 11.8; moderate-to-vigorous, 71.9 ± 22.6; and vigorous, 27.9 ± 11.7. No significant differences were observed between patients and controls for total physical activity (p = 0.80) or any of the intensities (p = 0.71, 0.46, 0.43, and 0.45, respectively). Only 40% of patients and controls met the new Canadian Physical Activity Guidelines for the Early Years of at least 180 minutes of physical activity at any intensity every day. Of the patients' parents, 90% believed that their child was as active, if not more active, than his/her siblings, and 80% of parents reported their child spending 1–3 hours in screen time activities daily. *Conclusion:* Children aged 3–5 years old with congenital heart disease have comparable physical activity levels to age-, sex-, and season-matched controls, and many do not meet Canadian Physical Activity Guidelines.

Keywords: Accelerometry; sedentary; early childhood; congenital heart disease; physical activity

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PHYSICAL INACTIVITY AND OBESITY ARE KEY CHILD health concerns of the 21st century. Children growing up with a chronic medical condition, such as congenital heart disease, may be at even greater risk for inactivity than the general population.[1] School-age children with congenital heart disease are known to engage in less moderate-to-vigorous physical activity than their healthy peers, independent of their exercise capacity.[2] However, investigations into the physical activity of children with congenital heart disease are typically restricted to children 6 years of age and older. Very little is known about physical activity of these patients during their early years, which may be an important time to instill healthy active living behaviours.[3] To the best of our knowledge, there have been no studies to objectively measure physical activity using accelerometers in 3- to 5-year-old children with congenital heart disease.

Studies have shown that reduced physical activity levels in school-age children with congenital heart

Correspondence to: Dr B. W. Timmons, PhD, Child Health & Exercise Medicine Program, McMaster University, HSC 3N27G, 1280 Main Street West, Hamilton, ON, Canada L8S 4K1. Tel: 905-521-2100, ext. 77615; Fax: 905-521-1073; E-mail: timmonbw@mcmaster.ca

disease are typically not related to cardiac status.[4] Parents, health-care providers, and other caregivers of children with congenital heart disease may over-restrict and impose unnecessary limitations, owing to the misconceptions about the risks and benefits of exercise for children with heart defects.[5,6] For example, in 4- and 5-year-old children with congenital heart disease, maternal worry was found to be a significant factor in influencing participation levels.[7] However, very little is known about parental perceptions of their child's physical activity level, especially in young children with congenital heart disease. Young children during the early years are likely to develop physical activity-related cognitions such as attitudes; however, through their belief-based actions, parents are in a position of strong control to enable or impair their child's physical activity behaviours.[8]

The primary objective of this study was to determine the physical activity levels of young children with congenital heart disease using high-frequency accelerometry and compare activity levels in patients with age-, sex-, and season of data acquisition-matched healthy controls. Given the previously reported low levels of physical activity among school-age children with congenital heart disease compared with their healthy peers,[9] we hypothesised that 3- to 5-year-old patients would have lower physical activity levels than healthy controls. As a secondary objective, we also examined parental perceptions of their child's physical activity.

Materials and methods

Study population

We identified children aged 3–5 years from the Pediatric Cardiology clinic at McMaster Children's Hospital as possible participants for this study, which was approved by the Hamilton Health Sciences/Faculty of Health Sciences Research Ethics Board. Coarctation patients were included if they were asymptomatic, normotensive, with no residual arm–leg blood pressure gradient, no aortic ischemic gradient by echo-Doppler, no left ventricular hypertrophy, and no arrhythmias; patients in this group were excluded if they had previously undergone more than one procedure for their coarctation, peak instantaneous Doppler velocity >1.8 m/second in the upper descending aorta, hypertension (defined as arm systolic blood pressure >95th%tile for age at rest), and/or left ventricular hypertrophy (septal and posterior wall dimensions >2 z-scores for body surface area). Patients with tetralogy of Fallot were included if they were asymptomatic, with no significant residual right ventricular outflow tract obstruction, pulmonary regurgitation not greater than moderate, right ventricular dimension z-score below 2.5, normal right ventricular pressure and function, no residual ventricular septal defect, no arrhythmias on electrocardiography or Holter, and QRS duration <120 ms. In all, 17 eligible patients were contacted by one of two cardiologists and invited to participate. Of them, seven patients did not participate because they were not interested or the cardiologist could not reach them by telephone. Characteristics of the 10 patients who agreed to participate are provided in Table 1. Parents provided written informed consent for their child's participation in this study. Data for healthy controls were drawn from our research database of children involved in previous studies on physical activity, and who had provided permission to have their data used for future studies approved by the Hamilton Health Sciences/Faculty of Health Sciences Research Ethics Board. The healthy controls were unknown to the patients.

Table 1. Participant characteristics.

	Patients (n = 10)	Controls (n = 10)
Male:female	6:4	6:4
Age (years)	4.0 ± 1.0	4.2 ± 1.0
Height (cm)	103.7 ± 8.2	104.5 ± 7.1
Height percentile	66.2 ± 19.6	61.1 ± 26.1
Weight (kg)	17.3 ± 2.7	17.3 ± 2.8
Weight percentile	66.3 ± 20.5	56.2 ± 29.5
BMI (kg/m^2)	16.1 ± 1.3	15.8 ± 1.4
BMI percentile	57.3 ± 30.3	45.9 ± 31.0
Overweight-obese (%)	10	20

BMI = body mass index

Values are presented as means ± SD. Percentile values calculated based on the Centers for Disease Control Growth Charts. Percentage of overweight/obese determined according to the International Obesity Task Force

Protocol

Each patient attended one session at McMaster University between January and March, 2010, where anthropometric measurements were assessed. Height and weight measurements were taken without shoes and while wearing light clothing. Standing height was measured to the nearest 0.1 cm and weight was measured to the nearest 0.1 kg. To assess physical activity, each participant was fitted with an ActiGraph GT1M (Fort Walton Beach, Florida, United States of America) accelerometer, which recorded movement and acceleration in the vertical plane. An epoch – or sampling interval – of 3 seconds was used to accurately capture the sporadic physical activity of young children.[10] The accelerometer was

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worn on the right hip for 7 consecutive days, and only removed during periods of sleeping and for water activities. Using an activity log book, the parent of each patient recorded the times when the accelerometer was taken off and replaced, as well as the reason for its removal. The parents also completed a questionnaire regarding the physical activity habits of their child. The same protocol had been followed by the healthy controls, although different investigators had measured height and weight, using the same methods. The healthy controls wore the accelerometer during the same month (±1 month) so as to minimise potential differences in activity based on seasonal conditions.

Physical activity assessment

Accelerometer data were downloaded and visually inspected to ensure the time recorded in the activity log book that matched the accelerometer output. Activity counts during reported times of non-wear were deleted. The data were then uploaded to a data reduction programme to determine total wear time, sedentary time, time spent in light, moderate, moderate-to-vigorous, and vigorous physical activity. The total time spent being physically active was determined by adding together the amount of time spent in light, moderate, and vigorous physical activity. To categorise activity intensity, we used cut-points previously developed using ActiGraph accelerometers in a healthy sample of 3- to 5-year-old children.[11] Sedentary time was defined as <8 counts/3 seconds, light physical activity was defined as 8–83 counts/3 seconds, moderate physical activity as ⩾84 counts/3 seconds but <168 counts/3 seconds, moderate-to-vigorous physical activity as ⩾84 counts/3 seconds, and vigorous physical activity as ⩾168 counts/3 seconds. Only participants who wore the accelerometer for ⩾5 hours on ⩾4 days, including 1 weekend day, were included in the analyses.

Statistical analysis

Physical activity and sedentary behaviour data were subjected to the Shapiro–Wilk test for normality. The coarctation of aorta and tetralogy of Fallot groups were first analysed separately for variables of physical activity and sedentary behaviour, but as no significant differences were detected, the data were pooled. Comparisons between patients and controls were then made by independent t-tests. Vigorous physical activity was not normally distributed, and therefore the Mann–Whitney U test was conducted to compare the patient and control group. To compare the proportion of patients and controls meeting physical activity recommendations, a χ^2-test was conducted. χ^2 tests were also conducted on the proportions of parents of patients and controls responding to questionnaire data. All statistical analyses were performed in SPSS (version 20.0, IBM, Chicago, Ilinois, United States os America). All data are presented as means ± SD, unless stated otherwise.

Results

Physical activity variables, sedentary time, and wear time in minute/day are shown in Table 2. On average, patients spent 219.4 ± 39.9 minutes/day engaged in total physical activity. Most of this activity was spent in light physical activity followed by moderate physical activity and then vigorous physical activity. A similar trend was observed in the controls. Overall, there were no significant differences detected for any physical activity variable, sedentary time, or wear time between patients and controls. We also expressed the physical activity and sedentary data as min/hour, but the results were the same.

The physical activity of patients and controls was then compared with the new Canadian Physical Activity Guidelines for the Early Years (aged 0–4 years), which recommend at least 180 minutes of physical activity at any intensity throughout the day.[12] In both the patient and control groups, 40% of the participants met the recommendation of at least 180 minutes of daily physical activity at any intensity. We also assessed the proportion of participants attaining the Canadian recommended 60 minutes of moderate-to-vigorous physical activity, for children 5 years and older.[13] In the patient group,

Table 2. Physical activity at different intensities, sedentary time, and wear time in patients and controls.

	Patients (n = 10)	Controls (n = 10)
TPA (minute/day)	219.4 ± 39.9	224.1 ± 44.0
(minute/hour)	19.8 ± 3.2	20.5 ± 2.6
LPA (minute/day)	147.5 ± 22.3	143.8 ± 21.7
(minute/hour)	13.3 ± 1.8	13.2 ± 1.3
MPA (minute/day)	44.0 ± 11.8	48.1 ± 12.7
(minute/hour)	4.0 ± 1.0	4.3 ± 0.8
MVPA (minute/day)	71.9 ± 22.6	80.3 ± 24.5
(minute/hour)	6.5 ± 1.9	7.3 ± 1.6
VPA (minute/day)	27.9 ± 11.7	32.2 ± 13.1
(minute/hour)	2.5 ± 1.0	2.9 ± 0.9
ST (minute/day)	446.8 ± 48.7	429.4 ± 37.8
(minute/hour)	40.0 ± 3.3	39.5 ± 2.6
WT (minute/day)	666.2 ± 46.7	653.5 ± 61.2

LPA = light physical activity; MPA = moderate physical activity; MVPA = moderate-to-vigorous physical activity; ST = sedentary time; TPA = total physical activity; VPA = vigorous physical activity; WT = wear time

Values are presented as means ± SD

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Table 3. Physical activity habits of children as reported by parents.

	Patients	Controls
Amount of time spent in some form of physical activity	(n = 10)	(n = 7)
20–45 minutes/day	20	0
1–2 hours/day	50	86
>2 hours/day	20	14
Not sure	10	0
Location where child plays actively outdoors	(n = 10)	(n = 9)
At a playground in the community	0	10
At school (e.g. recess, lunch, after-school)	10	20
In your own property	60	40
At a neighbourhood green space or park	10	0
At the day care provider	20	20
Not sure	0	10
Opinion of how much physical activity is required	(n = 10)	(n = 9)
20–45 minutes/day	20	0
1–2 hours/day	50	70
>2 hours/day	30	20
Not sure	0	10
Physical activity compared with siblings	(n = 10)	(n = 9)
As active	50	30
More active	30	10
Less active	0	0
No siblings	20	60
Is child as active as he/she should be?	(n = 10)	(n = 7)
Yes	90	43
No	0	29
Not sure	10	29
Amount of screen time (TV, video game, computer)	(n = 10)	(n = 9)
None	10	0
1–3 hours/day	80	100
>3 hours/day	10	0

Values are presented as percentages of each group. Numbers may vary because of rounding

30% of participants attained 60 minutes of moderate-to-vigorous physical activity every day. In the control group, 20% of participants attained the recommended daily amount.

According to the physical activity questionnaire completed by the parent, 70% of patients and 100% of controls spent at least an hour in some form of physical activity every day (Table 3). Patients tended to play actively outdoors in supervised locations, with 60% of patients playing in their own properties and 20% playing at their day care provider. All parents believed their child is as active, if not more active, than his/her siblings, where applicable. Of the patients' parents, 90% thought their child was as active as he/she should be, whereas only 43% of controls' parents thought their child was as active as he/she should be. The questionnaire also asked about sedentary behaviours: 80% of patients were reported to spend 1–3 hours watching television, playing video games, and/or on computer activities every day, with 10% participating in screen activities more than 3 hours every day and 10% not participating in any screen time activities. In contrast, 100% of the controls were reported to spend 1–3 hours a day participating in screen activities.

Discussion

To the best of our knowledge, this is the first study to examine the physical activity levels of 3- to 5-year-old children with congenital heart disease using high-frequency accelerometry. Although it is generally observed that school-age patients with congenital heart disease engage in lower levels of physical activity compared with their healthy peers,[9] we found

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that activity levels were comparable between younger patients and age-, sex-, and season-matched controls. We also found that parental perceptions of their child's physical activity did not correspond with objectively measured physical activity levels.

Until recently,[14] the focus of physical activity messages for children with congenital heart disease had been on restriction. In light of emerging evidence that reduced physical activity levels in school-age children with congenital heart disease are typically not related to cardiac status[4] or exercise capacity, per se,[2] efforts to promote physical activity for the majority of patients have recently been endorsed.[9] We studied the physical activity levels of young children because the early years are an important period to develop healthy active living behaviours.[3] We found that 3- to 5-year-old children with congenital heart disease had similar levels of physical activity of various intensities compared with healthy controls. This finding is similar to the results of a study that measured total energy expenditure of 7 children (average age of 5.7 years) with congenital heart disease using doubly labelled water and found that energy expenditure in physical activity (i.e., the difference between total energy expenditure and resting energy expenditure) was not different compared with 10 age-matched healthy controls.[15] Our results build on this finding by studying physical activity using accelerometers – the widely accepted standard in physical activity assessment – and comparing patients with controls at various intensities of physical activity. Notwithstanding the limited evidence regarding physical activity levels of patients during the early years, the available studies suggest that important changes occur in the physical activity habits of children with congenital heart disease during the transition from the early years into the school years. To fully understand this possibility, we recommend that longitudinal studies be conducted that follow the same cohort of patients over time beginning at an early age.

A secondary objective of this study was to examine parental perceptions of their child's physical activity. We found that parental perceptions of the patients' physical activity were inconsistent with objectively determined physical activity, such as believing their child was as active as he or she should be. This misconception is important to address, because it could be argued that apparent satisfaction with their child's physical activity level may reduce the likelihood of parental promotion for further physical activity. Our findings highlight the need for doctor–parent conversations about physical activity from a very early age, including the objective assessment of physical activity levels whenever feasible to do so. We also found that patients tended to play actively in locations close to home more often than controls. Although this finding is consistent with the literature showing that parents and other caregivers of children with congenital heart disease tend to over-restrict and impose unnecessary limitations,[5,14] it should be interpreted with caution. Factors such as location of residence, family income, and proximity to peers may all influence the location of active play; we did not measure or compare these variables between groups. Further understanding of such factors, including parental perceptions and beliefs in relation to their child's actual behaviours, would be a fruitful area of study, particularly for children with a chronic medical condition.

In this study, we acknowledge limitations that restrict our ability to make definitive conclusions. We do not know whether our sample is representative of all young children with congenital heart disease, although it is likely not. It will be important to repeat our study involving children with more limited cardiovascular function. We cannot discount the possibility that families who volunteered to participate in this study might already engage in an active lifestyle compared with those who did not choose to participate, although our results show that most of these children are still not meeting physical activity recommendations. Moreover, we did not assess a number of variables that may have an impact on participant physical activity behaviours, including socio-economic status, participant neighbourhood, or parental physical activity levels. Finally, we acknowledge the limitations of cross-sectional study designs, and propose that longitudinal studies are needed to fully understand physical activity trajectories of these patients from an early age.

In conclusion, 3- to 5-year-old children with congenital heart disease have comparable physical activity levels to age-, sex-, and season-matched controls, and many do not meet Canadian Physical Activity Guidelines. This study adds to the existing literature by documenting that parental perceptions may not reflect actual physical activity behavior in young children with congenital heart disease. The promotion of physical activity for young children with congenital heart disease is likely to benefit from an objective assessment of physical activity as part of routine clinical care.

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Conflicts of Interest

None.

Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the Tri-Council Policy Statement on human experimentation in Canada and with the Helsinki Declaration of 1975, as revised in 2008, and has been approved by the Faculty of Health Sciences/Hamilton Health Sciences Research Ethics Board.

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