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ORIGINAL ARTICLE

Pedometer-determined physical activity levels of healthy children and children with Down's syndrome

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ABSTRACT

Purpose: Children with Down's syndrome (DS) are considered sedentary and less engaged in recommended physical activity (PA) levels. This study compared the PA levels between children with DS and healthy children in Saudi Arabia.

Methods: The study included 85 children divided into two groups. The DS group comprised 37 children with DS aged 8–12 years recruited from the Down Syndrome Charitable Association and Al-Nahda Schools for DS. The healthy group comprised 41 healthy children aged 8–12 years recruited from regular schools in the same region. PA levels were measured over 7 days using a pedometer.

Results: The healthy group was more active than the DS group ($p < 0.05$). The total PA steps per minute had significant differences between the DS ($M = 7.979$, $SD = 2.21$) and healthy groups ($M = 17.512$, $SD = 3.08$; $p < 0.05$). The daily step count differed significantly on weekdays and weekends between the groups ($p < 0.05$).

Conclusions: The DS group had a high body mass index and physical inactivity compared with the second group. Obesity and physical inactivity among Saudi Arabian children with and without DS are major health concerns. Therefore, concerted efforts are needed to combat childhood obesity, promote PA, improve patient quality of life, and reduce the sedentary lifestyle among Saudi children and adolescents.

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Down's syndrome; pedometer; physical inactivity

Introduction

Down's syndrome (DS) is defined as a condition that is accompanied with intellectual disability (ID) and associated with abnormalities in chromosome 21 (Roizen and Patterson 2003). The incidence of DS births in the Kingdom of Saudi Arabia is 1.8 for every 1000 live births (Niazi et al. 1995); its prevalence in other Arabian countries is approximately 1.93–3.5 per 1000 live births (Murthy et al. 2006), while the overall incidence worldwide is approximately 1.25–1.67 per 1000 live births (Niazi et al. 1995; Murthy et al. 2006). Many individuals with DS have a sedentary lifestyle and less access to healthcare and experience poorer health than the general population (Baptista et al. 2005). Therefore, these individuals are at a risk for a multitude of secondary health problems and complications.

Maintaining adequate physical activity (PA) levels is important for healthy growth and development of children and establishment of healthy behaviors in the future. Accumulating evidence suggests that children and adolescents should have at least 60 min of daily moderate to vigorous PA to realize health-related benefits (Strong et al. 2005). Aerobic activities should be of either a moderate or vigorous intensity, defined as 3.0–5.9 and >5.9 metabolic equivalent units, respectively; however, vigorous-intensity activities should be performed at least 3 days/week (Committee PAGA 2008; Pitetti et al. 2013). Studies have shown that children with DS have low levels of PA and spend more time indoors compared with populations without DS (Varela et al. 2001; Bittles and Glasson 2004). Low levels of PA and obesity in individuals with DS may be related to a sedentary lifestyle (Draheim et al. 2002) and low motivation to be physically active (Kosma et al. 2002). The literature suggests that different PA programs for individuals with DS can significantly improve numerous health outcomes and characteristics related to primary and secondary elements of this population (Lotan 2007).

PA is defined as "any bodily movement produced by the skeletal muscles that result in energy expenditure". PA can include a variety of activities and patterns, which make the selection of exact and appropriate measurements very difficult. Therefore, PA must be measured by accurate and reliable assessment tools (Hinckson and Curtis 2013). However, PA is difficult to measure, especially when it is being assessed in children (Kohl et al. 2000). PA can be measured subjectively or objectively (Welk et al. 2000; Foley and McCubbin 2009; Phillips and Holland 2011). However, the preferred type of tools to assess PA varies on the basis of the objectives, design, and budget of the studies (Hinckson and Curtis 2013).

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Self-report tools, such as questionnaires, checklists, surveys, and adult proxies, are used to report recent participation in PA (Kohl et al. 2000). Generally, these measurements are reliable, valid, inexpensive, and easy to apply. However, questionnaire evaluations of PA among young children are affected by several factors, such as inaccurate recall and inability of children to estimate their time of participation in PA (Welk et al. 2000). Objective tools quantify and describe PA levels, producing information that is not affected by recall ability, ethnicity, or cultural status (Hinckson and Curtis 2013). Some objective tools can also collect data on the intensity, duration, and frequency of daily PA levels in children and youth (Whitt-Glover et al. 2006; Pitetti et al. 2009).

Step-counting devices (i.e., pedometers and accelerometers) provide a means of objectively quantifying total daily activity, and their counting mechanisms are particularly sensitive to detecting the recommended intensities of walking (Tudor-Locke et al. 2011). Accelerometers and pedometers are relatively easy to use and are reliable tools for measuring levels of PA in children. Accelerometers can provide data on PA aspects that describe the total intensity, amount, and period of physical inactivity (Foley et al. 2008; Ulrich et al. 2011). Pedometers can measure ambulation (e.g., walking or running), providing general assessment of PA levels. However, the data and information collected and obtained from accelerometers and pedometers are correlated (Corder et al. 2007).

The initial guidelines for pedometer use conclude that subjects should have accumulated at least 11 000 (for women) or 13 000 (for men) steps/day (Vincent and Pangrazi 2002). Another study by Tudor-Locke et al. (2011) used an empirical approach to assess the steps/day among children (aged 6–12 years) in relation to body mass index (BMI); they concluded that if the goal is to achieve a healthy BMI, boys and girls should accumulate $\geq$15 000 and $\geq$12 000 steps/day, respectively. Children who are not able to meet these standard steps per day are more likely to be classified to have an abnormal BMI (i.e., overweight or obese).

A recent research study has shown that boys who accumulated 13 000 steps per day and girls who accumulated 12 000 steps per day, which translates to approximately $\geq$60 min of moderate to vigorous PA, were considered active and met the recommended levels of PA (Rowlands and Eston 2005). However, recommendations for individuals with DS may be included under the PA guidelines for general populations (Kruger et al. 2009), which conclude that individuals with disabilities should have $\geq$60 min of moderate to vigorous PA. Previous studies documented that a large proportion of children and adolescents with DS may not meet the recommended level of daily activity (Oates et al. 2011; Esposito et al. 2012; Pitetti et al. 2013).

In general, studies related to PA among individuals with ID, including those with DS, are scarce and limited. Therefore, the purpose of the study is to describe and determine the levels of PA in children with DS. Understanding the pattern of PA in children with DS would help establish a good program for intervention, leading to increased PA levels in this population.

Methods

Participants

A sample of 85 children (40 children with DS and 45 healthy children) was initially recruited to serve as participants in this study. Seven participants were excluded from the final analysis owing to a failure to wear the pedometer as instructed. The final sample in this analysis comprised 78 participants who were then divided into two groups.

The DS group comprised 37 children with DS (aged 8–12 years) recruited from the Down Syndrome Charitable Association and Al-Nahda Schools, which are the two largest schools for children with DS in Riyadh, Saudi Arabia. The children with DS in both schools were distributed in their classrooms depending on their chronological ages. The healthy group comprised 41 healthy children of the same age range who were recruited from two regular schools in the same region.

A full clinical history, including illnesses, surgical interventions, and hospital stays, was collected for each individual. Both parents and children were informed regarding the aims and procedures of the study, as well as the possible risks and benefits. Written consent was obtained from all parents, guardians, and participants in this study. Ethical approval was granted by the research ethics committee of King Saud University. All the participants fulfilled the following inclusion criteria of DS: age between 8 and 12 years, male sex, ability to self-ambulate without any assistive devices, and ability to follow verbal instructions. Patients with any concurrent medical conditions that could affect the ability to walk a certain distance physically and those with severe visual, cognitive, or auditory disorders were excluded.

Study design

This study was a cross-sectional study that compared the PA levels and walking capacity between children with DS and healthy children.

Anthropometric measurements

The body weight of the patients in bare feet and with minimal clothing was measured twice using a Seca digital scale (model 770; Seca, Hamburg, Germany) and recorded to the nearest 0.1 kg. Their standing height was measured twice, with the children in bare feet and standing straight against a wall and recorded to the nearest 0.1 cm using a calibrated measuring rod (Seca Road Rod). BMI was calculated by dividing the weight (kg) by the height (m) squared. This number can be converted to an international percentile ranking to define normal ($<$85th percentile), overweight (85th–95th percentile), and obesity ($\geq$95th percentile) for each child (Cole et al. 2000).

PA assessment

PA was measured using a piezoelectric model pedometer (Omron HJ-112, Illinois, USA) for 7 continuous days. The

Omron HJ-112 ((Illinois, USA) is a small, lightweight piezoelectric pedometer, which indicates the total steps with a visual display that shows the current step count and has a button for resetting counts to zero (Hasson et al. 2009). The Omron HJ-112 pedometer was selected, since it is a particularly useful tool, especially compared with other measurement tools of PA; it is simple, easy to use, inexpensive, has enough memory capacity to store 7 consecutive days of data, and able to provide measurements that can be easily interpreted by researchers and patients (Crouter et al. 2005; Pitchford and Yun 2010).

Measurement procedure and protocol

On the first day of monitoring, the subjects received a sealed pedometer and full instructions regarding pedometer attachment. All participants in this study were instructed to attach the pedometer securely on the right waist in line with the mid-thigh using an elastic belt (Pitchford 2009) every day for 7 consecutive days. The subjects were also instructed to wear the pedometer from the time they woke up until the time they went to bed, excluding sleeping, bathing, and swimming, and to maintain their normal daily activities. Each morning at school, the researcher and assistants collected the pedometers, recorded the number of steps taken by the subjects, reset the pedometers to zero, prepared the pedometers for the next day, and returned them to the subjects. Based on the data set, the subjects asked for or were provided a brief log to determine whether they had removed the pedometer for more than 1 hour during a given day. The data acquired from the students who reported removing their pedometers for more than 1 hour were removed from the data set.

This protocol was similar to the protocols followed in previous research studies (Welk et al. 2000; Vincent and Pangrazi 2002; Tudor-Locke and Bassett 2004). Upon removal of the pedometers the following week, activity counts were restored, downloaded, and saved on a personal computer for analysis and data reduction. The pedometer was applied to both groups under supervision of the primary researcher, who clarified all questions regarding its performance and applications.

Statistical analysis

Descriptive statistics were performed for all variables in this study and presented as means (M), standard deviations (SDs), and frequencies or percentages (%). Analyses were performed using independent *t*-tests to identify differences, which could confound comparisons (e.g., age, weight, height, BMI), and results of PA (i.e., steps recorded by the pedometer and differences in the steps across weekdays and weekends). One-way ANOVA was employed to examine the differences across age groups and BMI categories within groups. An alpha value of $p \leq 0.05$ was set as the significant level. All statistical analyses were conducted using the Statistical Package of Social Science (SPSS-PC, Version 17.0; IBM, Armonk, NY, USA) software.

Results

The descriptive characteristics of the study sample are summarized in Table 1.

PA data in the healthy children and children with DS

An independent *t*-test was conducted to test the mean differences across the participant groups. Table 2 shows the main total PA (counts/min), pedometer data (steps/day and weekday/weekend steps), and pedometer wear time (min/day) between the children with DS and healthy children. The results demonstrated that the healthy children were more active than the children with DS ($p < 0.05$). The total PA steps per minute showed significant differences between the children with DS (M = 7.979, SD = 2.21) and the healthy children (M = 17.512, SD = 3.08) ($p < 0.05$). The results showed that the healthy children had twofold-higher values than the children with DS. However, the healthy children accumulated a mean of 9.533 counts/min, which was higher than that of the participants with DS ($p < 0.05$). The descriptive data of PA according to group are presented in Table 2 and Figure 1.

Mean differences in PA according to BMI category between the children with DS and healthy children

A one-way ANOVA was employed to compare the mean difference in the BMI category; all variables differed within groups ($p < 0.05$). Table 3 shows the pedometer counts in the normal weight, overweight, and obese participants.

Table 1. Descriptive data and mean differences between the healthy children and children with Down's syndrome according to age, weight, height, and BMI.

Variable	Group	*N*	Mean	SD	*p*-value
Age (years)	Healthy	41	10.53	1.71	0.28
	Down's syndrome	37	10.22	1.31	
Weight (kg)	Healthy	41	41.94	21.26	0.97
	Down's syndrome	37	42.10	16.28	
Height (cm)	Healthy	41	138.02*	14.49	0.003
	Down's syndrome	37	127.41*	15.50	
BMI	Healthy	41	21.23	4.50	0.23
	Down's syndrome	37	24.43	7.82	

*$p < 0.05$: healthy children vs. children with Down's syndrome; levels of significance for the mean differences are based on the independent *t*-test; BMI, body mass index.

Table 2. Descriptive data and mean differences between the healthy children and children with Down's syndrome according to PA data (pedometer data).

Variable	Group	*N*	Mean	SD	*p*-value
Total PA (counts/min)	Healthy	41	17.512*	3.08	0.000
	Down's syndrome	37	7.979*	2.21	
Steps (steps/day)	Healthy	41	13 712.46*	2862.76	0.000
	Down's syndrome	37	5797.892*	2820.67	
Weekday steps	Healthy	41	11 823.14*	2439.91	0.000
	Down's syndrome	37	5319.8*	2705.158	
Weekend steps	Healthy	41	18 698.74*	4667.78	0.000
	Down's syndrome	37	6993.12*	2765.286	
Wear time (hours/day)	Healthy	41	13.05	1.6	0.11
	Down's syndrome	37	12.11	1.32	

*$p < 0.05$: healthy children vs. children with Down's syndrome; levels of significance for the mean differences are based on the independent *t*-test. PA: physical activity.

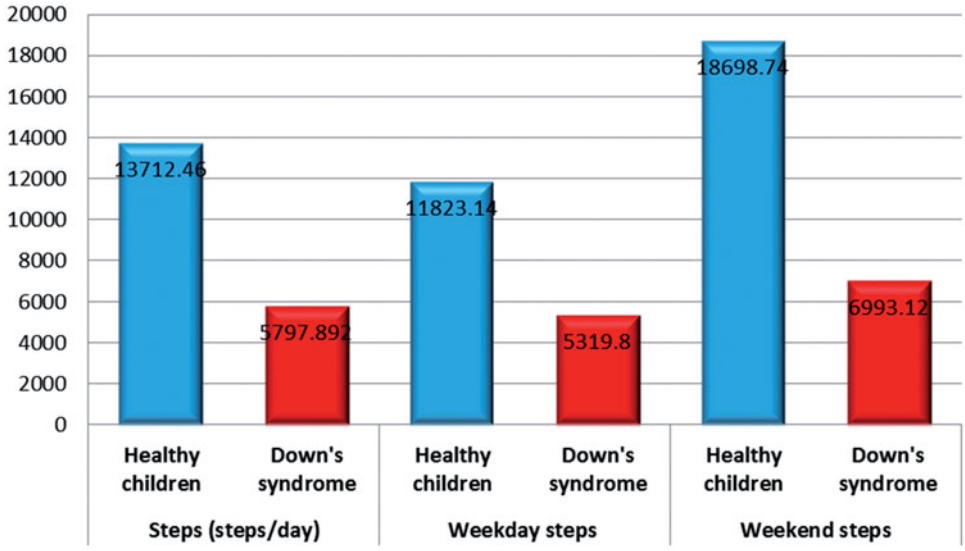

Figure 1. Mean differences in the steps/day, weekday steps, and weekend steps across the participants ($n = 78$).

Table 3. Mean differences in PA according to BMI category within the DS and healthy groups.

Variable	Group	BMI	*N*	Mean	SD	*p*-value
Total PA (counts/min)	Healthy	Normal weight	26	20.306*	2.97016	0.001**
		Overweight	8	16.461*	1.34144	
		Obese	7	11.896*	2.00171	
	DS	Normal weight	11	10.543*	2.32730	0.002**
		Overweight	13	7.9591*	1.05623	
		Obese	13	5.8358*	2.14669	
Steps (steps/day)	Healthy	Normal weight	26	15 899.79*	4277.02335	0.001**
		Overweight	8	12 889.63*	1931.67503	
		Obese	7	9314.57*	2882.45676	
	DS	Normal weight	11	7661.12*	2055.3493	0.002**
		Overweight	13	5778.85*	1520.97344	
		Obese	13	4240.36*	3091.23429	
Weekday steps	Healthy	Normal weight	26	13 822.32*	5436.946	0.018**
		Overweight	8	11 405.60*	1439.342	
		Obese	7	8159.20*	2480.122	
	DS	Normal weight	11	7117.75*	1997.588	0.006**
		Overweight	13	5236.06*	1523.388	
		Obese	13	3882.20*	3085.898	
Weekend steps	Healthy	Normal weight	26	21 093.46*	2849.653	0.000**
		Overweight	8	16 599.69*	3511.390	
		Obese	7	12 203.00*	4133.024	
	DS	Normal weight	11	9019.55*	1282.717	0.001**
		Overweight	13	7135.81*	1608.432	
		Obese	13	5135.77*	3204.714	

*$p < 0.05$: healthy children vs. children with DS based on the BMI category; the levels of significance for the mean differences are based on the *t*-test.
**$p < 0.05$: steps/day differs based on the BMI category; the levels of significance for the mean differences are based on one-way ANOVA.
PA: physical activity; BMI: body mass index; DS: Down's syndrome.

Mean differences in PA according to age within the DS and healthy groups

A one-way ANOVA was employed to compare the mean difference in the age category; all variables differed within groups ($p < 0.05$). To compare the mean differences between the participant groups, the data were split on the basis of each category, and then a *t*-test was conducted to compare between groups.

Table 4 displays the pedometer counts (steps per day) for the children with DS and healthy children across three age groups (8–9, 10–11, and 12–13 years). In all age groups, the healthy children had higher pedometer counts than the children with DS.

Discussion

The current study was proposed to provide valuable, indispensable information and objectively measured indicators for PA levels in children with DS compared with those in healthy children in Saudi Arabia. Furthermore, this study was proposed to provide information in relation to the age- and BMI-referenced PA levels of children with DS compared with those of healthy children in Saudi Arabia. Data on PA and walking capacity among children with DS in Saudi Arabia are limited and have not been extensively investigated. The current study aimed to describe and provide data on PA among children with DS in Saudi Arabia and found several clinically

Table 4. PA according to age group within the Down's syndrome and healthy groups.

Variable	Group	Age (years)	*N*	Mean	SD	Std. error	*p*-value
Healthy children	Total PA (counts/min)	8–9	10	19.610*	0.43	1.41214	0.12
		10–11	27	16.836*	2.26	0.46400	
		12–13	4	16.830*	1.35	0.74255	
	Steps (steps/day)	8–9	10	15 354.77*	629.83	2033.4874	0.12
		10–11	27	13 183.29*	3265.31	668.15480	
		12–13	4	13 178.64*	1945.53	1069.2665	
	Weekday steps	8–9	10	13 114.98*	1506.41	2707.4724	0.15
		10–11	27	11 373.63*	2714.22	544.15645	
		12–13	4	11 627.70*	1135.08	903.93504	
	Weekend steps	8–9	10	22 032.45*	2042.49	645.89442	0.029**
		10–11	27	17 707.41*	4937.93	1046.4442	
		12–13	4	17 056*	4145.38	1585.7719	
Children with Down's syndrome	Total PA (counts/min)	8–9	16	9.290*	1.29	0.34409	0.000**
		10–11	17	7.853*	1.59	0.56310	
		12–13	4	2.072*	0.44	0.28875	
	Steps (steps/day)	8–9	16	6750.66*	18 061.10	495.49148	0.000**
		10–11	17	5706.04*	2291.25	810.86934	
		12–13	4	1506.14*	640.46	415.79826	
	Weekday steps	8–9	16	6415.43*	1879.36	501.99293	0.000**
		10–11	17	5297.38*	2260.37	1019.9107	
		12–13	4	1157.20*	484.39	391.71085	
	Weekend steps	8–9	16	8288.75*	1885.58	502.10222	0.000**
		10–11	17	6859.50*	2399.34	478.87171	
		12–13	4	2378.12*	1039.37	493.24922	

*$p < 0.05$: healthy children vs. children with Down's syndrome based on age category; the levels of significance for the mean differences are based on the *t*-test.
**$p < 0.05$: steps/day differ on the basis of the age category; the levels of significance for the mean differences are based on one-way ANOVA. PA: physical activity.

significant findings that need further research in this population.

In general, PA among different populations can be assessed by a variety of objective and subjective measurement means (Eiholzer et al. 2003; Foley et al. 2008; Foley and McCubbin 2009; Phillips and Holland 2011; Ulrich et al. 2011). We used the pedometer to measure PA because it is an objective tool of measuring such and is suitable for clinical and public health applications owing to its low cost and primarily to the interpretability for the users (i.e., clinicians and public health providers) (Tudor-Locke and Myers 2001; Craig et al. 2010). The piezoelectric pedometers (Omron HJ112 model) were recommended by researchers to minimize the effects of walking speed and body composition on measurement error, especially for samples of individuals with DS (Pitchford 2009). Nevertheless, pedometers have been found as accurate and valid tools of measuring PA (in terms of measuring the steps per day) in research and practice (Schneider et al. 2003; Hasson et al. 2009).

It has been agreed on by many studies that children with ID in general experience greater inactivity than healthy children, which was also observed in children with DS (Faison-Hodge and Porretta 2004; Whitt-Glover et al. 2006; Foley et al. 2008; Phillips and Holland 2011; Matute-Llorente et al. 2013). Our assumption in this study is that children with DS have lower levels of PA than healthy children. The results confirmed our assumption and showed that the children with DS accumulated lower pedometer step counts per day (5797.892) than the healthy children (13 712.46). Our study findings are consistent with the findings of most of the previous international studies; particularly, one study investigated 17 Swiss children and adolescents with Prader–Willi syndrome with a mean age of 11 ± 7 years and found that their subjects had lower pedometer step counts per day (4635) than the individuals without disability (5723) (Eiholzer et al. 2003). However, Beets et al. (2007) reported lower pedometer step counts per day among their 40 subjects aged 10 ± 3 years with development disability. In addition, Phillips and Holland (2011) demonstrated that their participants with DS were significantly less active than those with other IDs and that the levels of activity significantly declined with age. Moreover, Matute-Llorente et al. (2013) reported that individuals with DS had lower total counts and pedometer step counts per day than their control group.

The healthy participants in the current study accumulated a mean step count per day of 13 712.46, which was consistent with the pedometer counts (13 864–15 023) reported in Australian children aged 6–12 years (Vincent and Pangrazi 2002). Higher pedometer step counts per day (11 589) were found among American children aged 10–13 years (Le Masurier et al. 2005); however, lower pedometer step counts per day were reported by Cox et al. (2006) (15 606) in New Zealand children and by Rowlands and Eston (2005) in British children aged 8–10 years (16 035).

In the current study, we found that the children with DS significantly covered lower steps per day both on weekends (6993.12) and weekdays (5319.8) ($p < 0.05$) than those without DS (18 698.74 vs. 11 823.14, respectively). These results proved our hypothesis that there is a significant difference in the pedometer-determined daily step count values on weekdays and weekends between children with DS and healthy children in Saudi Arabia. Conversely, opposite findings were observed in the study by Kim and Yun (2009) that used an Omron HJ112 pedometer to evaluate PA in 16 children with and without DS aged 12–20 years. It was found that the steps of individuals with DS were significantly higher during weekdays (8299; SD, 2433 steps/day) than during weekends (5858; SD, 4098 steps/day). Similarly, opposite findings were

observed in the study by Dixon-Ibarra et al. (2013) that used pedometer information to evaluate PA in 109 participants with and without DS aged 18–50 years. It was found that the steps of individuals with DS were significantly higher during weekdays than during weekends. This difference in the levels of PA during weekdays and weekends might be because of the nature of activities in school and with families at home; further, it might have also resulted from the nature of the school days in Saudi Arabian schools and other countries where children spend long hours sitting inside classrooms, and the PA classes are limited only to 1 or 2 hours weekly.

Based on the results of our study that showed remarkable differences in the levels of PA participation during weekdays and weekends among children with DS in Saudi Arabia, we suggest that it is important to investigate further the reasons why the children with DS in Saudi Arabia had higher levels of PA participation during weekends than during weekdays, to sort out activity types, and to apply them on weekdays to promote overall PA. It is important to integrate the educational process to provide a healthy atmosphere that would help children in their growth, creating balance in all aspects (i.e., mental, psychological, physical, and emotional growth). Therefore, identifying the reasons leading to the lack of children's participation in sports activities is essential, while also searching for solutions to such and creating plans and programs to increase children's participation in PAs during weekdays at schools. It is important to provide training programs to children with DS and care providers at school or at home and enhance their knowledge via participations in workshops and training courses inside and outside Saudi Arabia to reach optimal levels of PA for these children.

Limitations of the study

Our study has some limitations that should be considered when interpreting the findings and results:

(1) *Study design*. The cross-sectional design of this study prevented us from exploring the causal relationships clearly. Whether the obesity among the boys in this study is due to the reduced levels of PA or inactivity remains unclear. However, our results are consistent with those of numerous other studies showing relationships between physical inactivity and obesity indices.

(2) *Sample size*. In this study, the sample size limited the generalization of the results to DS and general populations. The sample size particularly on the individuals with DS was small owing to difficulties in recruiting DS group participants. The sample studied may not be representative of the entire Saudi population; it was limited only to the Riyadh population. However, considering that Riyadh is the largest city and a major commercial center of Saudi Arabia that attracts workers, students, and visitors from different parts of the country, we believe that the sample and therefore the study results can be extrapolated to the rest of the Saudi population.

(3) *Pedometer limitations in walking*. Pedometers cannot measure some types of PA, such as duration of activity, intensity of PA during assessment of free-living, upper body activities, and non-weight-bearing activities (e.g., swimming, load carrying, and cycling). However, only few participants performed higher levels of these activities.

(4) *Sex limitation*. We examined only the PA and the 6-min walk test (6MWT) in male subjects without including female participants because of the cultural nature of the society and the laws in Saudi Arabia, and in response to the desire of parents not to include their daughters in the study.

Conclusions

Our study found a high BMI and high prevalence rate of physical inactivity among the Saudi Arabian children with DS aged 8–12 years compared with the healthy children. Therefore, there is a need to establish good strategies, programs, and early interventions designed to promote the recommended levels of PA and improve the quality of life among individuals with DS.

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Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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