RBCDH Revista Brasileira de CINEANTROPOMETRIA e Desempenho Humano

DOI: http://dx.doi.org/10.5007/1980-0037.2014v16n2p182

original article

Physical fitness in children with probable developmental coordination disorder and normal body mass index

Aptidão física em crianças com provável transtorno do desenvolvimento da coordenação e índice de massa corporal normal

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Abstract – Changes in body mass index (BMI) due to various factors, such as a low level of physical activity, are often associated with poor physical fitness in children with probable developmental coordination disorder ($_p$DCD). This study examined whether children with $_p$DCD would show poorer performance in terms of physical fitness when compared with their typically developing (TD) peers. Thirty two children with $_p$DCD and normal BMI and other 32 children with TD and normal BMI, matched by gender, age and BMI, performed the sit and reach, standing long jump, curl-up, modified pull-up and 9-min run tests. The children in the $_p$DCD group showed lower explosive power, muscle strength and endurance, and cardiorespiratory fitness than children in the TD group. Overall, children with $_p$DCD had lower levels of physical fitness, even with normal BMI.

Key words: Children; Developmental coordination disorder; Physical Fitness.

Resumo – *Mudanças no índice de massa corporal (IMC), devido a diversos fatores, como o baixo nível de prática de atividade física, são frequentemente associadas ao baixo nível de aptidão física de crianças com provável transtorno do desenvolvimento da coordenação ($_p$TDC). O presente estudo examinou se crianças com $_p$TDC apresentariam desempenhos inferiores em termos de aptidão física quando comparado com seus pares de desenvolvimento típico (DT). Trinta e duas crianças com $_p$TDC e IMC normal e 32 crianças com DT e IMC normal, pareadas por gênero, idade e IMC, realizaram os testes de sentar e alcançar, de salto horizontal, abdominal, puxada na barra 'modificado' e corrida de 9-min. Os resultados mostraram que crianças do grupo $_p$TDC apresentaram menor força explosiva, resistência e força muscular e resistência cardiorrespiratória do que as crianças do grupo TD. Foi concluído que, mesmo com IMC esperado para a idade, crianças com $_p$TDC têm baixo nível de aptidão física.*

Palavras-chave: *Aptidão física; Crianças; Transtorno do desenvolvimento da coordenação.*

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Received: 03 May 2013
Accepted: 22 August 2013

INTRODUCTION

Developmental coordination disorder (DCD) is a clinical condition with unknown etiology characterized by low motor competence. One concept used in clinical practice to diagnose a child with DCD is that low motor competence cannot be associated with any neurological impairment or mental deficit[1]. According to the American Psychiatric Association[1], a small portion of children show difficulty performing simple daily motor actions at home and/or at school. Children with such a disorder, which becomes apparent during the course of development, have low motor competence when compared with children of the same age and gender who have typical motor development. In the last decade, much of the research efforts related to DCD have focused on neural, cognitive, physical, and psychosocial aspects, to elucidate both the underlying mechanisms and the impact of this disorder on the daily lives of these children[2].

Recently, a number of studies have shown that children with DCD show poor performance in health-related physical fitness components. In particular, their physical fitness performance is substantially lower than that of their typically developing (TD) counterparts in the components explosive power, muscle strength and endurance[3-7], and cardiorespiratory fitness[4,6,8-10]. However, performance differences in physical fitness components between children with DCD and TD children were not confirmed in a sample with very young children at four to six years of age[6], and the distinction is still ambiguous for the flexibility component[11].

The reduced performance in physical fitness components observed in children with DCD is frequently associated with various factors. According to previous studies, these factors include a lack of engagement in physical activity[12], inaccurate perception of their competence to perform physical activities[13,14], and high levels of body mass index (BMI)[15,16]. Although the relationship between physical activity, BMI, and physical fitness is relatively well established in the literature for the general population[17], such a relationship is not yet well understood in children with DCD. In previous studies, children were selected for comparison regardless of BMI, which may jeopardize the analysis of data, as the presence of overweight or obese children in any of the groups tends to skew the results related to physical fitness components[5-7]. A question of interest, therefore, is whether a normal BMI for age can alter physical fitness, especially in children with DCD. To the best of our knowledge, the present study is the first to rigorously control for normal BMI for age in all participants. If an elevated BMI was a sole factor contributing to physical fitness components, then children with DCD would be expected to show a performance similar to that of their TD peers matched by age, gender and normal BMI for age. Therefore, the purpose of the present study was to examine physical fitness (e.g., explosive power, muscle strength and endurance, cardiorespiratory fitness, and flexibility) in children with DCD and TD children with normal BMI for age.

METHODOLOGICAL PROCEDURES

Sample

The present study included 64 girls and boys recruited from three public schools in São Paulo state who were aged between 7 to 10 years and had an age-appropriate normal BMI. Data from children who were overweight or obese were not included in this study. Thirty-two children identified with motor difficulties in the Movement Assessment Battery for Children 2 (MABC-2)[18] composed the 'probable' DCD ($_p$DCD) group, and other 32 children matched by gender and age without motor difficulties composed the TD group (Table 1). The participants were selected for this study based on the results of MABC-2 and anthropometric measures taken previously to the assessment of physical fitness test battery.

We adopted the $_p$DCD designation because our means of identifying children's motor competence was through results of a field test administered by trained researcher assistants, not by a diagnostic protocol administered by a physician[19]. Furthermore, our procedure did not consider all criteria described in the Diagnostic and Statistical Manual of Mental Disorders[1] for DCD. We were not able to determine, for instance, whether children's motor difficulties were affecting their activities of daily living (Criterion B). Given the complexity of establishing the impact of motor difficulties on the activities of daily living, the procedure of selecting children adopted in the present study is typical of research in this area[5,19,20]. Although the MABC-2 is not a gold standard test to diagnose children with and without DCD, it provides a reasonable view of basic motor abilities functioning of each child.

All procedures for testing protocols were performed at the children's school, in an appropriate room, administered by members of the laboratory who received training to administer the protocols. The parents or guardians of each child gave written informed consent prior to participation in the study. All procedures adopted in the study were approved by a University Ethics Committee (Universidade Estadual Paulista, Campus Rio Claro) by number 8386.

Anthropometric assessment

BMI was calculated using the weight and height of each participant. Three measurements were made for weight and height, using the median of the three measures to calculate the BMI. The following formula was used for the calculation of BMI: Weight/Height^2. According to standard cut-off points for BMI in children, taking into account difference in gender, the participants were identified as having a normal BMI or being overweight or obese[21]. Only the data for participants identified as having a normal BMI were included for the data analysis in the present study.

Motor assessment

The MABC-2 was used to assess motor coordination[18]. This battery consists of three tasks of manual dexterity, two tasks of aiming and catching and three tasks of balance. Each child was assessed individually at his/her school in a safe and appropriate room. The performance of the tasks of the MABC-2 was based on the execution time or on the number of correct executions. After the application of the test battery, the raw data for each participant were converted into scores according to the instructions in the MABC-2 manual. According to the instructions, normalization of the total battery score as a percentile established that when a child received a score equal to or less than the 5th percentile, he or she was diagnosed with significant motor coordination difficulties; when a child received a score equal to or less than the 15th percentile, he or she was strongly considered at risk of having motor difficulties; when a child received a score greater than the 15th percentile, he or she was identified as having no motor difficulties. For the purpose of the present study, children scoring equal to or below the 15th percentile on the MABC-2 comprised the $_p$DCD group. Children scoring equal to or above the 25th percentile on the MABC-2 formed the TD group. The duration of the motor assessment for each child was approximately 25 minutes, and all procedures were in accordance with the guidelines suggested by the authors[18].

Table 1. Mean and standard deviation (in parenthesis) of age, height, weight, BMI (body mass index) and total percentile of MABC-2 (Movement Assessment Battery for Children-2) of TD (typically developing) and pDCD (probable developmental coordination disorder) groups.

	TD (F = 16; M = 16)	$_p$DCD (F = 16; M = 16)
	Mean (SD)	Mean (SD)
Age (year)	8.4 (0.9)	8.4 (0.8)
Height (m)	1.33 (0.06)	1.31 (0.09)
Weight (kg)	28.5 (4.13)	27.54 (4.67)
BMI (weight/height^2)	15.99 (1.36)	15.87 (1.34)
MABC-2 percentile	63 (24.4)	8 (5.7)

Physical fitness assessment

All participants were submitted to five health-related physical fitness tests according to standard protocols. The selection of the test protocols to examine physical fitness in the present study was based on the work of Guedes and Guedes[22] who established percentile scores for a sample of Brazilian children. The physical fitness tests used by these authors provide indicators to measure flexibility, explosive power, muscle strength and endurance, and cardiorespiratory fitness. The sit and reach test was used to measure the flexibility of the lower back and the hamstrings. Children were asked to sit on the floor with the soles of their feet against a box of 30 cm height and to lean forward with straight arms as far as possible, placing one hand on the top of the other on the surface of the box along the measuring scale. The leg explosive power was examined using the standing long jump test repeated three times. The best performance was saved for further analysis. The children were required to jump as far as possible using both legs and swinging the arms. Muscle strength and endurance of the abdominal muscles was examined based on the curl-up test. The number of correctly executed curl-ups in one minute was recorded. Muscle strength and endurance of the upper body was investigated using the modified pull-up test in which the maximum number of correct repetitions in one attempt was recorded. This test required a wooden frame to support a metal bar in a horizontal position at a particular height, just reachable to each participant while lying on his/her back on a flat and comfortable surface. Each repetition consisted of a movement where the body is raised up by flexing the arms until the chin is lined up with the horizontal bar, and then the body is lowered back by extending the arms to the starting position. Cardiorespiratory fitness was assessed using the 9-min run test in which the children were required to run or walk, but not to stop, for nine minutes around a sports court. The travelled distance covered within nine minutes was registered for further analysis. The tests were conducted in groups of five children with approximately 40 minutes of duration.

Statistical treatment

The Statistica 8.0 software was used for the statistical analyses. The effect size (ES) was calculated using the G*Power software[23]. For $d = .20$, the ES is small; for $d = .50$, the ES is moderate; and for $d = .80$, the ES is great. The normality of data was verified using the Shapiro-Wilk test. The comparison of physical fitness between children with $_{p}$DCD and TD with normal BMI for age was done using the Student's t test for parametric data and the Mann-Whitney test for nonparametric data. Alpha level was set at .05.

RESULTS

The results from the Student's t test indicated that the performance of the $_{p}$DCD group was significantly lower than that of the TD group for the standing long jump test, $t(62) = 2.9$, $p < .01$, $d = .78$, and the 9-min run test, $t(62) = 2.5$, $p < .05$, $d = .63$. With respect to the sit and reach test, there was no significant difference in the performance between $_{p}$DCD and TD groups, $t(62) = 1.41$, $p > .05$, $d = .32$ (Table 2). The results from the Mann-Whitney test indicated that the performance of $_{p}$DCD group was significantly lower than that of the TD group for the modified pull-up test, $Z(64) = 2.2$, $p = .02$, $d = .66$ and the curl-up test, $Z = 2,21$, $p < .05$, $d = .53$. ES values for each variable with statistical difference were considered moderate.

Table 2. Mean and standard deviation (in parenthesis) for physical fitness tests of the TD (typically developing) and pDCD (probable developmental coordination disorder) groups.

	TD	$_{p}$DCD
	Mean (SD)	Mean (SD)
Sit and reach (cm)	23.6 (5.7)	21.3 (7.4)
Standing long jump (cm)	114.1 (16.8)	98.6 (24.8)
[2]Modified pull-up (rep.)	9.7 (5.8)	6.6 (4.4)
[2]Curl-up (rep.)	22.2 (7.7)	18.1 (8.4)
9-min Run (m)	1221.6 (229.9)	1097.7 (153.7)

[2] Mann-Whitney test; cm, centimeter; rep., repetition; m, meter; TD, typically developing; $_{p}$DCD, probable developmental coordination disorder.

DISCUSSION

The present study investigated physical fitness in children with $_p$DCD and TD children. The strength of the current study is that it includes only children with a normal BMI for their age in both groups. BMI was controlled to distinguish the possible effect of being overweight or obese on physical fitness, especially for the $_p$DCD group. The results of the present study indicated that children with $_p$DCD showed significantly poorer performance on physical fitness tests than their TD peers in the components of cardiorespiratory fitness, muscle strength and endurance, and explosive power. Overall, the results of the present study are similar to a number of previous studies that did not match the groups in terms of normal BMI for age[5,7,24].

A number of studies, especially those using field-based protocols, such as the Legér 20-m shuttle run[5,7,13,19,24], the 6-m run[6,24,25] and the 800-m run[5], have consistently found that cardiorespiratory fitness in children with $_p$DCD is lower than that in TD children. Among the variables accounting for the poor cardiorespiratory fitness of these children are the perceptions of the subjects' own abilities in which children with $_p$DCD do not feel physically as adequate compared with TD children[14]. Low levels of physical activity also contribute for poor cardiorespiratory fitness. Silman et al.[20], for example, measured the levels of activity of children with DCD with an accelerometer for seven days and found that these children were less active compared with their TD counterparts. Overweight/obesity and elevated body fat are also variables that mediate the differences in cardiorespiratory fitness between the groups[15]. Evidence from field-based protocols of poor cardiorespiratory fitness in children with DCD has recently gained support from the results of laboratory-based protocols. For example, results from studies using the incremental treadmill protocol showed that the VO_2 peak was approximately 20% lower in the DCD group compared with control group[9,26]. Children with DCD were more likely to give up of the task without reaching their best performance[9] than their TD peers, and consequently their cardiorespiratory fitness is underestimated.

One of the few studies that did not find evidence of poor cardiorespiratory fitness in children with DCD was a study conducted by Tsiotra et al.[7] using the Legér 20-m shuttle run. According to these authors, Greek children in general demonstrate lower aerobic fitness compared with children from other countries, which may have made it difficult to distinguish a statistical difference between the DCD and TD groups. According to the authors, Greek children in general exhibit lower levels of cardiorespiratory fitness compared with samples from other countries. Furthermore, an examination on the results of Schott et al.[6] also showed no difference between the DCD and TD groups for cardiorespiratory fitness measured by 6-m run test, especially for subgroups of younger children aged four to nine years, but not for the older group aged ten to twelve years. Cardiorespiratory fitness in children with DCD may be mediated by factors such as the physical education curriculum and the age band. One could argue that performing the Legér 20-m shuttle run or covering the greatest distance by running for 6 minutes might leave children with DCD at a disadvantage because of their own coordination problems. Cairney et al.[10] showed evidence that children with DCD exerted similar effort to their peers without DCD in individual cycle ergometer testing, despite significant differences in VO_2.

Consistent with the literature, the children with $_p$DCD in the present study also showed lower physical fitness in the components of muscle strength and endurance and explosive power[5-7,24,25]. Physical fitness tests commonly used for assessment of these components are the Curl-up, Push-up, Standing broad jump and Medicine ball chest pass tests. It is possible that similarly to the performance on cardiorespiratory fitness laboratory tests, children with $_p$DCD might give up without trying their best in these tests. However, the Curl-up, Modified push-up and Standing long jump tests used in the present study require a greater demand for neuromuscular coordination compared with that of cardiorespiratory fitness tests. The poor performance of these children in the tests involving the components of explosive power of the lower limbs and muscle strength and endurance of the abdominal and upper limbs occurs as a function of their own motor coordination difficulties. The type of tasks used to assess these components exhibits a degree of complexity that requires interlimb and intralimb coordination. In particular, the tests of the Standing long jump, Curl-up and Modified push-up used in the present study require the subject to generate and sustain adequate muscle force contraction in a timing-specific manner for each task. Additionally, the results indicated no difference in the performance of the flexibility test between $_p$DCD and TD groups, which is consistent with some previous studies[6,7]. Such similarity is due, in part, to the fact that the test used to assesses flexibility does not require complex neuromuscular coordination, thereby leaving the $_p$DCD group equal with their TD peers[7].

Whether the source of the poor performance of children with $_p$DCD in this set of tasks is related or not to neuromuscular coordination is a matter that requires further investigation. In addition, difficulties in neuromuscular coordination might be related to deficits in force control. There is evidence that children with DCD show some deficits in the production of force and explosive power[27] as well as in force control[28]. Of interest to this study is the fact that an equivalent BMI for children of both groups did not reveal the deficiencies of the $_p$DCD group, giving support to the view that the performance of physical fitness tests in the $_p$DCD group might also be determined by the neuromuscular coordination demands of the tasks. Differences in flexibility observed in previous studies[3, 29] are explained by the heterogeneous profile of children with DCD, showing great variability in flexibility or rigidity.

In the present study, when the groups were controlled for normal BMI, in addition to gender and age, children with $_p$DCD actually performed poorer on physical fitness tests when compared to their TD peers. We cannot infer about the effects of an elevated BMI on the level of physical fitness in $_p$DCD children. However, our findings demonstrated that a normal BMI does not warranty a better performance on physical fitness tests in children with $_p$DCD compared to their TD peers. It is recommended that studies involving comparisons between DCD and TD groups match children by age, gender and BMI (specifically, children who are overweight). In previous studies, children with DCD have consistently shown an elevated BMI compared with their TD peers[15,16,30]. It is possible that the presence of children who are overweight or obese may enhance or diminish the differences between the groups, depending on the presence of these children in one or both groups. The predominance of overweight or obese children in one group may aggravate the poor performance of these children not only in physical fitness tasks but in other tasks as well, such as those associated with global motor coordination.

CONCLUSIONS

The present study examined physical fitness in children with $_p$DCD compared to their TD peers. We controlled for BMI by including only children with a normal BMI and excluding those who were overweight or obese. We may therefore conclude that, even when matched for normal BMI, age, and gender, children with $_p$DCD continue to demonstrate poor physical fitness for the components explosive power, muscle strength and endurance, and cardiorespiratory fitness, but not for flexibility.

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