Cadernos Brasileiros de Terapia Ocupacional
Brazilian Journal of Occupational Therapy

ISSN 2526-8910

Original Article

Assessing physical activity levels, body mass index, and waist circumference in children with and without developmental coordination disorder

Avaliação dos níveis de atividade física, índice de massa corporal e circunferência da cintura em crianças com e sem transtorno do desenvolvimento da coordenação

Jorge Lopes Cavalcante Neto[a], Tatiane Targino Gomes Draghi[b], Liz Araújo Rohr[c], Eloisa Tudella[c]

[a]Universidade do Estado da Bahia – UNEB, Jacobina, BA, Brasil.
[b]Centro Universitário Nossa Senhora do Patrocínio, Itu, SP, Brasil.
[c]Universidade Federal de São Carlos – UFSCar, São Carlos, SP, Brasil.

How to cite: Cavalcante Neto, J. L., Draghi, T. T. G., Rohr, L. A., & Tudella, E. (2025). Assessing physical activity levels, body mass index, and waist circumference in children with and without developmental coordination disorder. *Cadernos Brasileiros de Terapia Ocupacional*, *33*, e3849. https://doi.org/10.1590/2526-8910.ctoAO396538492

Abstract

Objective: To evaluate differences in levels of physical activity, body mass index (BMI), and waist circumference between children with DCD and their typically developing (TD) peers. Additionally, we correlated motor performance, BMI, and physical activity levels in these children. **Method:** Three hundred twenty-nine children aged 7-10 years participated: 96 with severe DCD (s-DCD), 94 with moderate DCD (m-DCD), and 139 TD children. The Movement Assessment Battery for Children-Second Edition (MABC-2) and the Physical Activity Questionnaire for Children (PAQ-C) assessed motor performance and physical activity levels, respectively. Children's BMI and waist circumference (WC) were assessed using standard procedures. **Results:** Most children were classified as sedentary (74.0% s-DCD, 80.9% m-DCD, 71.9% TD). No significant differences in physical activity levels were found between motor performance groups. Children with s-DCD had significantly larger waist circumferences ($p < 0.01$) and higher BMIs ($p = 0.03$) than the TD group. **Conclusions:** The low levels of physical activity observed, regardless of motor performance, are concerning. Children with s-DCD had significantly higher waist circumference and BMI than other groups, which is not explained by physical activity levels in this sample.

Keywords: Developmental Coordination Disorder, Physical Activity, Child, Sedentary Behavior.

Received on May 23, 2024; 1st Revision on Sept. 30, 2024; Accepted on Oct. 31, 2024.

Resumo

Objetivo: Avaliar diferenças nos níveis de atividade física, índice de massa corporal (IMC) e circunferência da cintura entre crianças com transtorno do desenvolvimento da coordenação (TDC) e seus pares com desenvolvimento típico (TD). Além disso, nós correlacionamos os scores de desempenho motor, IMC e níveis de atividade física das crianças. **Método:** No total, 329 crianças entre 7-10 anos de idade participaram do estudo, 96 com TDC severo (s-TDC), 94 com TDC moderado (m-TDC) e 139 TD. A MABC-2 e o Questionário de Atividade Física para crianças (PAQ-C) foram usados para avaliar o desempenho motor e os níveis de atividade física, respectivamente. O IMC e a circunferência da cintura (CC) das crianças foram avaliados por procedimentos padronizados. **Resultados:** A maioria das crianças foi classificada como sedentária (74% das s-TDC, 80,9% das m-TDC e 71,94% das TD). Entretanto, não foram observadas diferenças significativas nos níveis de atividade física entre os grupos de crianças por desempenho motor. Crianças com s-TDC tiveram significativamente maior CC ($p<0,01$) e IMC mais elevado ($p = 0,03$) do que o grupo TD. **Conclusões:** Os baixos níveis de atividade física são preocupantes, independente do desempenho motor. Crianças s-TDC tiveram significativamente valores mais elevados de CC e IMC do que os demais grupos, o que não foi explicado pelos níveis de atividade física na amostra estudada.

Palavras-chave: Transtorno do Desenvolvimento da Coordenação, Atividade Física, Criança, Comportamento Sedentário.

Introduction

Investments in health indicators have increased globally. Alarmingly, the prevalence of overweight and obesity has also risen in recent years. Despite the wealth of knowledge available today, there's a disconnect between this knowledge and people's lifestyles. Maintaining physical activity is widely recognized as crucial for improving fitness and reducing the risk of adverse health outcomes, including overweight and obesity. As reported by Hands & Larkin (2006), decreased physical activity levels are associated with a higher risk of overweight and obesity. Consequently, this can lead to cardiovascular diseases, diabetes, and hypertension (Al-Goblan et al., 2014; Jiang et al., 2016; Telama et al., 2005).

Furthermore, certain populations appear to be at a higher risk of overweight or obesity associated with low levels of physical activity. Among these groups, children with developmental coordination disorder (DCD) are frequently cited in studies as a potential risk group for overweight, obesity, and a sedentary lifestyle (Kwan et al., 2016; Li et al., 2011; Lopes et al., 2012; Rivilis et al., 2011).

DCD, a significant motor disorder affecting approximately 5% of school-age children (American Psychiatric Association, 2022; Blank et al., 2019; Smits-Engelsman et al., 2015) interferes with school, daily and leisure activities (American Psychiatric Association, 2022; Blank et al., 2019; Girish et al., 2016), which often results in a noticeable lack of participation (Mandich et al., 2003; Mimouni-Bloch et al., 2016).

Moreover, children with DCD often prefer activities requiring less energy expenditure, as they may experience frustration when participating in sports alongside their typically developing peers (Cairney et al., 2005). Importantly, the activity deficit

observed in children with DCD tends to persist into adulthood (Cairney et al., 2010). Therefore, research to understand the relationship between physical activity levels and overweight or obesity is crucial for a comprehensive understanding of DCD.

Straker et al. (2011) proposed a vicious cycle model to elucidate the relationship between poor sensory-motor integration, reduced participation in leisure activities, and the consequent health implications for children with DCD. In this model, children with DCD are at a higher risk of having inadequate physical activity levels because their leisure activities are not sufficiently linked to good fitness levels (Rivilis et al., 2011), leading them to favor sedentary activities (Hay et al., 2004).

While a significant portion of children and adolescents can adhere to systematic physical activity practices or programs promoted through public health campaigns, most children with DCD lack sufficient motivation to engage in activities that would increase their physical activity levels (Capistrano et al., 2015; Santos et al., 2020). They require more than simple recommendations to change their sedentary lifestyle and become active (Joshi et al., 2015). This aligns with the contextualization proposed by Straker et al. (2011) and the activity deficit hypothesis by Bar-Or (2012). Both arguments converge, suggesting that motor impairments in these children hinder their adequate participation in physical activities, consequently leading them toward a sedentary lifestyle rather than a physically active one. Therefore, targeted assessments and interventions focusing on a dynamic biopsychosocial model may be more beneficial for children with DCD (Blank et al., 2019). Furthermore, an accurate diagnosis is crucial before researchers can plan specific interventions.

In Brazil, particularly, there is no formal diagnosis for children with DCD, and this condition remains unfamiliar to many parents and teachers (Caçola & Lage, 2019). Additionally, epidemiological estimates have revealed alarming data on the prevalence of obesity in Brazilian citizens, reaching approximately 24% (Ferreira et al., 2019). This trend is also observed in children and youth, with prevalence rates around 15% (Guerra et al., 2016), strongly associated with low levels of physical activity (Guerra et al., 2016; Silva et al., 2018). Considering that at least 5% of these prevalence rates comprise children with DCD, it is crucial to be concerned about the negative impact of DCD on health (Santos et al., 2020). Both DCD and overweight/obesity exhibit an early onset of characteristics, suggesting they may share similar genetic and contextual risk factors (Gambra et al., 2024). However, there is no clear evidence regarding the relationship between DCD and overweight/obesity in children (Hendrix et al., 2014). Conversely, there is a strong link between both DCD and overweight/obesity and not meeting the guidelines for daily physical activity levels (Gambra et al., 2024; Rivilis et al., 2011), which for children should exceed 60 minutes per day (World Health Organization, 2019, 2020).

Therefore, new and more specific investigations are needed to assess physical activity levels and body mass index to understand whether Brazilian children with DCD are at a greater risk of overweight, obesity, and low levels of physical activity compared to their typically developing peers. We hypothesized that children with DCD would have significantly lower levels of physical activity and higher BMIs than typically developing children. Thus, this study aimed to evaluate differences in physical activity levels, body mass index (BMI), and waist circumference between children with developmental coordination disorder and their typically developing peers Additionally, we examined the correlations between motor performance, BMI, and physical activity levels in these children.

Methods

This is a cross-sectional study conducted in public and private schools in the city of São Carlos, São Paulo, Brazil. The local Ethics Committee approved this study (protocol number 47091115000005504). All parents signed an Informed Consent Form to authorize their children's participation in the study. Children also signed an Assent Form before any research procedures.

Participants

A total of 329 children aged 7-10 years, of both genders, enrolled in nine selected schools participated in this study. All children were assessed according to the Diagnostic and Statistical Manual for Mental Disorders – 5 (DSM-5) diagnostic criteria for DCD (American Psychiatric Association, 2022) as follows: Children's motor performance was evaluated using the Movement Assessment Battery for Children – second edition (MABC-2) to identify motor deficits based on age and opportunities for practice (Criterion A); Children's parents completed a Developmental Coordination Disorder Questionnaire (DCDQ) to identify signs of DCD based on parental perception (Criterion B); Children's parents answered specific questions regarding their children's development (Criterion C) and the presence of disabilities or other clinical conditions in their children (Criterion D).

Recruitment followed these steps: (i) Consent Forms, DCDQs, and sociodemographic questionnaires (including specific questions about DSM diagnostic criteria for DCD) were distributed to each enrolled child to take home to their parents; (ii) One week later, the materials were collected at school to verify the number of fully completed questionnaires and signed consent forms. A total of 329 out of 835 returned questionnaires were eligible for this study; (iii) Physical activity levels, motor skills, and anthropometric assessments were conducted for the 329 eligible children at their schools.

Variables and instruments

Children's motor performance was evaluated using the MABC-2, which comprises three components: manual dexterity, aiming & catching, and balance. Within each domain, children perform specific tasks, and their scores are based on time taken and errors made. A total standard score and component scores are assigned to children based on their age band and task performance. Children's motor performance is classified according to percentile values: ≤5th percentile: presence of significant motor difficulties; <16th percentile: at risk for motor difficulties; and >16th percentile: no motor difficulties detected (Henderson et al., 2007). Specifically for this study, we classified children following previous recommendations (Smits-Engelsman et al., 2015): ≤5th percentile: severe DCD (s-DCD); <16th percentile: moderate DCD (m-DCD); and 16th percentile: typically developing children (TD).

Children's physical activity levels were assessed using the Physical Activity Questionnaire for Children (PAQ-C). The PAQ-C is a self-administered questionnaire with nine items related to participation in various physical activity settings over the past 7 days, including physical education (PE) classes and activities outside of school

(Kowalski et al., 1997). The PAQ-C has been translated and adapted for Brazilian culture (Guedes & Guedes, 2015), demonstrating reasonable psychometric properties, with internal consistency (α = 0.71) and test-retest reproducibility (intraclass correlation coefficient [ICC]) ranging from 0.68 to 0.82 (Guedes & Guedes, 2015). Each item is scored from 1 (low physical activity) to 5 (high physical activity). The overall physical activity level is determined by the mean score of the nine items, classifying children as: sedentary (score ≤ 2), moderately active (score > 2 and ≤ 3) and Active (score > 3). The PAQ-C was self-administered under the supervision of an assessor.

Children's height was measured using a stadiometer, and weight was measured using an electronic scale. BMI (kg/m^2) was calculated by dividing weight in kilograms by height in meters squared. BMI classifications (underweight, healthy weight, overweight, and obese) followed World Health Organization (2014) guidelines.

Waist circumference (WC) was measured at the midpoint between the iliac crest and the lower rib after normal expiration, using an anthropometric measuring tape (World Health Organization, 2000). All measurements were performed by a physical education professional and a physiotherapist, each with over 10 years of experience in motor development and trained with the instruments used.

Statistical analysis

Children's sociodemographic characteristics were presented as means, standard deviations, and percentages. One-way ANOVA was used to compare differences in PAQ-C scores, weight, height, BMI, and waist circumference between the children's motor performance groups (s-DCD, m-DCD, TD). Pairwise comparisons with Bonferroni correction were performed when significant differences were found. The significance level for all comparisons was set at 5%. Additionally, Pearson's correlation was used to assess the relationships between MABC-2 Total Score (MABC-2 TS), BMI, and PAQ-C mean values. Correlation strength was interpreted based on the following: 1 – Negligible (0.00-0.10); 2 – Weak (0.10-0.39); 3 – Moderate (0.40-0.69); 4 – Strong (0.70-0.89); and 5 – Very strong (0.90-1.00) (Schober et al., 2018). All analyses were conducted using SPSS version 20.0.

Results

A total of 329 children participated in this study. Based on motor performance classification, 96 children were identified as s-DCD, 94 as m-DCD, and 139 as TD. These and other descriptive characteristics are shown in Table 1.

Regarding children's physical activity levels, the majority in all motor performance classifications were classified as sedentary (74.0% s-DCD, 80.9% m-DCD, and 71.94% TD). According to BMI evaluations, the most frequent classification in all motor performance groups was “healthy weight” (45.83% s-DCD, 49.93% m-DCD, and 61.15% TD). However, combined, both s-DCD (33.33%) and m-DCD (32.97%) groups had higher percentages of children with obesity compared to the TD group (17.26%).

Table 1. Descriptive characteristics of children between motor classification groups.

Variables	s-DCD	m-DCD	TD	Total
Age (years)*	8.87 (0.98)	8.59 (0.95)	9.17 (0.96)	8.92 (0.99)
MABC – 2 TTS*	47.14 (8.30)	62.13 (3.30)	78.17 (7.21)	64.54 (14.62)
Gender**				
Girls	36 (20.7%)	54 (31%)	84 (48.3%)	174 (100%)
Boys	60 (38.7%)	40 (25.8%)	55 (35.5%)	155 (100%)
PAQ-C**				
Sedentary	71 (74.0%)	76 (80.9%)	100 (71.94%)	247 (75.07%)
Moderately active	22 (22.9%)	15 (16.0%)	33 (23.74%)	70 (21.27%)
Active	03 (3.1%)	03 (3.2%)	06 (4.31%)	12 (3.64%)
Total	96 (100%)	94 (100%)	139 (100%)	329 (100%)
BMI**				
Underweight	01 (1.04%)	02 (2.12%)	01 (0.71%)	04 (1.21%)
Eutrophic	44 (45.83%)	46 (48.93%)	85 (61.15%)	175 (53.19%)
Overweight	19 (19.79%)	15 (15.95%)	29 (30.85%)	63 (19.14%)
Obesity	32 (33.33%)	31 (32.97%)	24 (17.26%)	87 (26.44%)

*Data showed in mean and standard deviation. **Data showed in absolute and relative (%) frequencies. s-DCD: severe Developmental Coordination Disorder; m-DCD: moderate Developmental Coordination Disorder; TD: Typically Developing.

Significant differences in waist circumference ($p < 0.01$) and BMI ($p = 0.03$) were observed between groups (Table 2). Pairwise comparisons showed that the s-DCD group had a significantly larger waist circumference ($p < 0.01$) and a higher BMI ($p = 0.03$) than the TD group. No significant differences were found between s-DCD and m-DCD ($p = 0.94$) or between m-DCD and TD ($p = 0.16$) for waist circumference. Similarly, no significant differences were found between s-DCD and m-DCD ($p = 1.00$) or between m-DCD and TD ($p = 0.26$) for BMI.

A Pearson correlation analysis was performed to estimate the strength of the relationships between MABC-2 and BMI, and between MABC-2 and PAQ-C. A significant negative correlation was observed between MABC-2 and BMI ($r = -0.175$; $p < 0.01$). However, no significant correlation was found between MABC-2 and PAQ-C ($r = 0.07$; $p = 0.21$) (Table 3).

Table 2. Comparison analyses of weight, height, waist circumference, BMI and PAQ-C between groups of children.

Variables*	s-DCD	m-DCD	TD	p-value
Weight	37.60 (±11.39)	36.04 (±13.30)	35.43 (±8.51)	0.32
Height	137.78 (±0.79)	135.78 (±0.96)	139.06 (±0.71)	0.49
Waist circumference	68.45 (±11.39)	66.84 (±12.87)	64.01 (±9.24)	<0.01
BMI	19.53 (±4.42)	19.07 (±4.73)	18.15 (±3.18)	0.03
PAQ-C	2.59 (±0.60)	2.51 (±0.54)	2.66 (±0.59)	0.17

*Data showed in mean and standard deviation. s-DCD: severe Developmental Coordination Disorder; m-DCD: moderate Developmental Coordination Disorder; TD: Typically Developing.

Table 3. Correlation analysis between MABC-2 TS and BMI of children.

Variables	r	p-value
MABC-2 TS/BMI	- 0.175	< 0.01
MABC-2 TS/PAQ-C	0.07	0.21

Discussion

This study aimed to identify differences in physical activity levels, body mass index (BMI), and waist circumference between children with DCD and their typically developing peers. Additionally, we examined the correlations between motor performance, BMI, and physical activity levels in these children.

No significant differences in physical activity levels, as measured by PAQ-C scores, were observed between the motor performance groups. We had hypothesized that children with DCD would exhibit significantly lower physical activity levels compared to TD children. However, previous studies (Batey et al., 2014; Cermak et al., 2015) did find significantly lower levels of physical activity and more sedentary behavior in children with DCD compared to their typically developing peers. In contrast, another study reported no significant differences in physical activity levels between children with and without motor delays (King-Dowling et al., 2018). It's important to consider some differences between the children in these studies and our own. For instance, our study included children aged 7-10 years, while King-Dowling et al. (2018) focused on children around 5 years old, and Batey et al. (2014) examined children aged 13-14 years. Only Cermak et al. (2015) had a similar age range of 6-11 years. These age discrepancies might contribute to the variation in results. However, if inadequate habits persist throughout childhood and adolescence, sedentary behavior is likely to become ingrained in the routines of school-age children.

In this regard, sedentary behavior was the most frequent classification across all children's groups. This finding suggests that Brazilian children need to engage in more playground activities or sports, and this issue appears to be independent of motor coordination problems, at least within this population. As observed in our study, the majority of school-age children in Brazil are sedentary, regardless of their motor performance classification related to DCD. This reinforces previous evidence from Brazilian studies (Guerra et al., 2016), which found that high body weight and low levels of physical activity were the most common factors associated with sedentary behavior in children and adolescents in the country.

Complementarily, the World Health Organization (2011) recommends a minimum of 60 minutes of moderate-to-vigorous physical activity per day for children and adolescents aged 5-17 years. Our results indicate that Brazilian children are far from meeting this recommendation. These findings may be attributed to cultural factors and raise concerns about a potential public health problem.

This finding also underscores the role of Physical Education (PE) classes during the school years in Brazil. For decades, PE teachers in Brazil primarily focused on sports rules and offered limited activities. However, there's a shift towards promoting opportunities for children to explore their motor skills through various activities. Unfortunately, many PE teachers still lack awareness about DCD (Caçola & Lage,

2019). Moreover, PE classes may not be an inclusive environment for all children. In many cases, children might participate but not be actively engaged. A study conducted in the Brazilian context (Coledam et al., 2018) revealed that students actively participating in PE classes had the best health-related outcomes. However, the current structure of PE classes in Brazilian schools may not adequately protect students from overweight or obesity (Coledam et al., 2018). Collaboration between occupational therapists (OTs) and PE teachers could be an effective strategy to achieve better outcomes at schools. Additionally, more engaging physical activity programs are recommended, especially for children with engagement difficulties, such as those with DCD (Zaragas et al., 2023). Alternatively, active video games (Cavalcante Neto, 2020) offer a promising avenue to promote regular physical activity for children with DCD (Cavalcante Neto et al., 2019). These games can increase motivation, provide immediate feedback (Mouatt et al., 2019), and improve motor skills, potentially opening doors for children with DCD to engage in non-virtual activities with greater confidence and motivation (Cavalcante Neto et al., 2020). Furthermore, active video game interventions can be supervised by a multidisciplinary team, including PE teachers, OTs, or physiotherapists, which is widely recommended for children with DCD (Blank et al., 2019).

Given that children with DCD often face challenges in actively engaging in physical activities, the following recommendations are crucial for professionals in the field of human movement, such as PE teachers and occupational therapists: Children with DCD tend to be slower than their peers, perform movements with less accuracy, and often require more effort for common movements. Considering these factors, some strategies should be implemented for these children, including promoting group instruction, providing cues for learning, utilizing goal setting and routine-based approaches, adopting a product-based approach, and taking into account the constraints-led perspective in movement skill acquisition (Caçola & Romero, 2015). Additionally, partnering with children's parents is essential to raise awareness about DCD in schools and society, and to enhance the participation of these children in physical activities (O'Kelly & Fourie, 2023; Steenbergen et al., 2024).

Therefore, further research is needed to better understand sedentary behavior in school-age children and explore other factors that might explain the expected relationship between physical activity levels and motor performance in children.

Regarding BMI and waist circumference, children with s-DCD exhibited a higher body mass index and larger waist circumference than typically developing children, but this significant difference was not observed in children with m-DCD. Similarly, other studies (Cermak et al., 2015; Hendrix et al., 2014; Joshi et al., 2015) found a significant association between body mass, increased overweight, and DCD (considering all levels of motor difficulty). Joshi et al. (2015) and Hendrix et al. (2014) also concluded that waist circumference was larger in children with DCD than in typical controls. Collectively, these findings suggest an increased risk of overweight in children with DCD. Our results further highlight that the greater the motor difficulty, the greater the risk of becoming obese, which is also supported by the significant negative correlation observed between MABC-2 and BMI values. As MABC-2 scores increase (indicating better motor performance), BMI tends to decrease, and vice versa.

Our findings reinforce the vicious cycle previously described (Straker et al., 2011), as impaired motor skills can discourage children with DCD from participating in physical activity, potentially contributing to weight gain and higher BMIs. Therefore, it is crucial to break this cycle. By improving their motor performance, these children can become more skilled and confident in engaging in physical activities, which may help prevent weight gain and reduce the risk of various adverse health outcomes.

This study has two main limitations. First, we did not investigate the children's diets, which could be associated with weight gain. Additionally, exploring compulsive eating behaviors, often linked to anxiety and depression, could enhance our understanding of these issues. Previous studies have reported symptoms of anxiety and depression in children with DCD (Draghi et al., 2020, 2021), making a detailed investigation considering all these factors a particularly interesting avenue for future research. Second, we did not use more precise instruments to measure body fat percentage, which would provide more detailed information about weight gain. However, despite its limitations, BMI remains a valuable tool for assessing obesity risk. Its simple calculation, requiring only weight and height, allows for efficient use of time in primary healthcare or community settings. Especially in many Brazilian contexts, where resources are limited, health-related assessments like BMI can help prevent serious risks in both childhood and adulthood.

Conclusion

Children exhibited low levels of physical activity, irrespective of their motor performance. Although no significant differences were observed in physical activity levels between the motor performance groups, the s-DCD group had a higher waist circumference and BMI, which cannot be explained by physical activity levels alone.

Acknowledgements

The authors thank all children and their parents for participating in our research.

References

Al-Goblan, A. S., Al-Alfi, M. A., & Khan, M. Z. (2014). Mechanism linking diabetes mellitus and obesity. *Diabetes, Metabolic Syndrome and Obesity*, *7*, 587-591.

American Psychiatric Association – APA. (2022). *Diagnostic and statistical manual of mental disorders (DSM-5-TR)*. Washington: APA.

Bar-Or, O. (2012). *Pediatric sports medicine for the practitioner: from physiologic principles to clinical applications*. New York: Springer.

Batey, C. A., Missiuna, C. A., Timmons, B. W., Hay, J. A., Faught, B. E., & Cairney, J. (2014). Self-efficacy toward physical activity and the physical activity behavior of children with and without Developmental Coordination Disorder. *Human Movement Science*, *36*, 258-271.

Blank, R., Barnett, A. L., Cairney, J., Green, D., Kirby, A., Polatajko, H., Rosenblum, S., Smits-Engelsman, B., Sugden, D., Wilson, P., & Vinçon, S. (2019). International clinical practice recommendations on the definition, diagnosis, assessment, intervention, and psychosocial aspects of developmental coordination disorder. *Developmental Medicine and Child Neurology*, *61*(3), 242-285.

Caçola, P., & Lage, G. (2019). Developmental Coordination Disorder (DCD): an overview of the condition and research evidence. *Motriz*, *25*(2), e101923.

Caçola, P., & Romero, M. (2015). Strategies to accommodate children with developmental coordination disorder in physical education lessons. *Journal of Physical Education, Recreation & Dance*, *86*(9), 21-25.

Cairney, J., Hay, J. A., Faught, B. E., Wade, T. J., Corna, L., & Flouris, A. (2005). Developmental coordination disorder, generalized self-efficacy toward physical activity, and participation in organized and free play activities. *The Journal of Pediatrics*, *147*(4), 515-520.

Cairney, J., Hay, J. A., Veldhuizen, S., Missiuna, C., & Faught, B. E. (2010). Developmental coordination disorder, sex, and activity deficit over time: a longitudinal analysis of participation trajectories in children with and without coordination difficulties. *Developmental Medicine and Child Neurology*, *52*(3), e67-e72.

Capistrano, R., Ferrari, E. P., Beltrame, T. S., & Cardoso, F. L. (2015). Developmental coordination disorder and level of physical activity in children: systematic literature review. *Cadernos Brasileiros de Terapia Ocupacional*, *23*(3), 633-646.

Cavalcante Neto, J. L. (2020). Virtual Reality interventions' effects on functional outcomes for children with neurodevelopmental disorders. In C. M. Hayre, D. J. Muller & M. J. Scherer (Eds.), *Virtual reality in health and rehabilitation* (1st ed.). Boca Raton: CRC Press.

Cavalcante Neto, J. L., Oliveira, C. C., Greco, A. L., Zamunér, A. R., Moreira, R. C., & Tudella, E. (2019). Is virtual reality effective in improving the motor performance of children with developmental coordination disorder? A systematic review. *European Journal of Physical and Rehabilitation Medicine*, *55*(2), 291-300.

Cavalcante Neto, J. L., Steenbergen, B., Zamunér, A. R., & Tudella, E. (2020). Wii training versus non-Wii task-specific training on motor learning in children with developmental coordination disorder: a randomized controlled trial. *Annals of Physical and Rehabilitation Medicine*, *64*(2), 1-6.

Cermak, S. A., Katz, N., Weintraub, N., Steinhart, S., Raz-Silbiger, S., Munoz, M., & Lifshitz, N. (2015). Participation in physical activity, fitness, and risk for obesity in children with developmental coordination disorder: a cross-cultural study. *Occupational Therapy International*, *22*(4), 163-173.

Coledam, D. H. C., Ferraiol, P. F., Aguiar Greca, J. P., Teixeira, M., & Oliveira, A. R. (2018). Physical education classes and health outcomes in Brazilian students. *Revista Paulista de Pediatria*, *36*(2), 192-198.

Draghi, T. T. G., Cavalcante Neto, J. L., Rohr, L. A., Jelsma, L. D., & Tudella, E. (2020). Symptoms of anxiety and depression in children with developmental coordination disorder: a systematic review. *Jornal de Pediatria*, *96*(1), 8-19.

Draghi, T. T. G., Cavalcante Neto, J. L., & Tudella, E. (2021). Symptoms of anxiety and depression in schoolchildren with and without developmental coordination disorder. *Journal of Health Psychology*, *26*(10), 1519-1527.

Ferreira, A. P. S., Szwarcwald, C. L., & Damacena, G. N. (2019). Prevalência e fatores associados da obesidade na população brasileira: estudo com dados aferidos da Pesquisa Nacional de Saúde, 2013. *Revista Brasileira de Epidemiologia*, *22*, e190024.

Gambra, L., Cortese, S., Lizoain, P., Romero, D. R., Paiva, U., Gándara, C., Arrondo, G., & Magallón, S. (2024). Excessive body weight in developmental coordination disorder: a systematic review and meta-analysis. *Neuroscience and Biobehavioral Reviews*, *164*, 105806.

Girish, S., Raja, K., & Kamath, A. (2016). Prevalence of developmental coordination disorder among mainstream school children in India. *Journal of Pediatric Rehabilitation Medicine*, *9*(2), 107-116.

Guedes, D. P., & Guedes, J. E. R. P. (2015). Medida da atividade física em jovens brasileiros: reprodutibilidade e validade do PAQ-C e do PAQ-A. *Revista Brasileira de Medicina do Esporte*, *21*(6), 425-432.

Guerra, P. H., Farias Júnior, J. C., Florindo, A. A., & Florindo, A. A. (2016). Sedentary behavior in Brazilian children and adolescents: a systematic review. *Revista de Saude Publica*, *50*, 9.

Hands, B., & Larkin, D. (2006). Physical fitness differences in children with and without motor learning difficulties. *European Journal of Special Needs Education*, *21*(4), 447-456.

Hay, J. A., Hawes, R., & Faught, B. E. (2004). Evaluation of a screening instrument for developmental coordination disorder. *The Journal of Adolescent Health*, *34*(4), 308-313.

Henderson, S. E., Sugden, D. A., & Barnett, A. (2007). *Movement assessment battery for children* (2nd ed.). London: Pearson. Retrieved in 2024, May 23, from https://www.pearsonclinical.com/therapy/products/100000433/movement-assessment-battery-for-children-second-edition-movement-abc-2.html

Hendrix, C. G., Prins, M. R., & Dekkers, H. (2014). Developmental coordination disorder and overweight and obesity in children: a systematic review. *Obesity Reviews*, *15*(5), 408-423.

Jiang, S.-Z., Lu, W., Zong, X.-F., Ruan, H.-Y., & Liu, Y. (2016). Obesity and hypertension. *Experimental and Therapeutic Medicine*, *12*(4), 2395-2399.

Joshi, D., Missiuna, C., Hanna, S., Hay, J., Faught, B. E., & Cairney, J. (2015). Relationship between BMI, waist circumference, physical activity and probable developmental coordination disorder over time. *Human Movement Science*, *40*, 237-247.

King-Dowling, S., Rodriguez, C., Missiuna, C., Timmons, B. W., & Cairney, J. (2018). Health-related fitness in preschool children with and without motor delays. *Medicine and Science in Sports and Exercise*, *50*(7), 1442-1448.

Kowalski, K. C., Crocker, P. R. E., & Faulkner, R. A. (1997). Validation of the physical activity questionnaire for older children. *Pediatric Exercise Science*, *9*(2), 174-186.

Kwan, M. Y. W., King-Dowling, S., Hay, J. A., Faught, B. E., & Cairney, J. (2016). Longitudinal examination of objectively-measured physical activity and sedentary time among children with and without significant movement impairments. *Human Movement Science*, *47*, 159-165.

Li, Y.-C., Wu, S. K., Cairney, J., & Hsieh, C.-Y. (2011). Motor coordination and health-related physical fitness of children with developmental coordination disorder: a three-year follow-up study. *Research in Developmental Disabilities*, *32*(6), 2993-3002.

Lopes, V. P., Stodden, D. F., Bianchi, M. M., Maia, J. A. R., & Rodrigues, L. P. (2012). Correlation between BMI and motor coordination in children. *Journal of Science and Medicine in Sport*, *15*(1), 38-43.

Mandich, A. D., Polatajko, H. J., & Rodger, S. (2003). Rites of passage: understanding participation of children with developmental coordination disorder. *Human Movement Science*, *22*(4-5), 583-595.

Mimouni-Bloch, A., Tsadok-Cohen, M., & Bart, O. (2016). Motor difficulties and their effect on participation in school-aged children. *Journal of Child Neurology*, *31*(11), 1290-1295.

Mouatt, B., Smith, A., Mellow, M., Parfitt, G., Smith, R., & Stanton, T. (2019). The use of virtual reality to influence engagement and enjoyment during exercise: a scoping review. *Journal of Science and Medicine in Sport*, *22*(2), S98.

O'Kelly, N. L., & Fourie, J. V. (2023). Journeying with developmental coordination disorder: the family experience. *African Journal of Disability*, *12*, 1-10.

Rivilis, I., Hay, J., Cairney, J., Klentrou, P., Liu, J., & Faught, B. E. (2011). Physical activity and fitness in children with developmental coordination disorder: a systematic review. *Research in Developmental Disabilities*, *32*(3), 894-910.

Santos, V. A. P., Ferreira, L., Both, J., Caruzzo, N. M., & Vieira, J. L. L. (2020). Longitudinal study changes in coordination development disorder in preschool children. *Cadernos Brasileiros de Terapia Ocupacional*, *28*(4), 1180-1192.

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation coefficients: appropriate use and interpretation. *Anesthesia and Analgesia*, *126*(5), 1763-1768.

Silva, D. A. S., Christofaro, D. G. D., Ferrari, G. L. M., Silva, K. S., Nardo, N., Silva, R. J. S., & Fernandes, R. A. (2018). Results from Brazil's 2018 report card on physical activity for children and youth. *Journal of Physical Activity & Health*, *15*(s2), S323-S325.

Smits-Engelsman, B., Schoemaker, M., Delabastita, T., Hoskens, J., & Geuze, R. (2015). Diagnostic criteria for DCD: past and future. *Human Movement Science*, *42*, 293-306.

Steenbergen, B., Valtr, L., Dunford, C., Prunty, M., Bekhuis, H., Temlali, T. Y., van Abswoude, F., Lust, J. M., Warlop, G., Augustijn, M., Smits-Engelsman, B. C. M., & Wilson, P. H. (2024). Awareness about developmental coordination disorder. *Frontiers in Public Health*, *12*, 1345257.

Straker, L. M., Campbell, A. C., Jensen, L. M., Metcalf, D. R., Smith, A. J., Abbott, R. A., Pollock, C. M., & Piek, J. P. (2011). Rationale, design and methods for a randomised and controlled trial of the impact of virtual reality games on motor competence, physical activity, and mental health in children with developmental coordination disorder. *BMC Public Health*, *11*, 654.

Telama, R., Yang, X., Viikari, J., Välimäki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood. *American Journal of Preventive Medicine*, *28*(3), 267-273.

World Health Organization – WHO. (2000). *Obesity: preventing and managing the global epidemic* (World Health Organization Technical Report Series, No. 894, 253 p). Geneva: WHO.

World Health Organization – WHO. (2011). *Global recommendations on physical activity for health*. Geneva: WHO.

World Health Organization – WHO. (2014). *WHO child growth standards: methods and development.* Geneva: WHO.

World Health Organization – WHO. (2019). *Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age*. Geneva: WHO.

World Health Organization – WHO. (2020). *Guidelines for physical activity and sedentary behaviour*. Geneva: WHO.

Zaragas, H., Fragkomichelaki, O., Geitona, M., Sofologi, M., Papantoniou, G., Sarris, D., Pliogou, V., Charmpatsis, C., & Papadimitropoulou, P. (2023). The effects of physical activity in children and adolescents with developmental coordination disorder. *Neurology International*, *15*(3), 804-820.

Author's Contributions

Jorge Lopes Cavalcante Neto, Tatiane Targino Gomes Draghi, Liz Araújo Rohr and Eloisa Tudella were responsible for conceiving the article. All authors approved the final version of the text.

Funding Source

This study was granted by the Sao Paulo Research Foundation – FAPESP, under the number 2015/24291-0. The costs for publication were granted for the State University of Bahia, PROFORTE Program, number 039/2023.

Corresponding author

Jorge Lopes Cavalcante Neto
e-mail: jorgelcneto@hotmail.com

Section editor

Iza de Faria-Fortini