Academic Journal of
Pediatrics & Neonatology
ISSN 2474-7521

Juniper Publishers
key to the Researchers

Mini Review
Volume 9 Issue 2 - February 2020
DOI: 10.19080/AJPN.2020.09.555814

Acad J Ped Neonatol

Exercise Interventions and Evaluation Tools of the Cardiovascular Capacity in Children with Developmental Coordination Disorder

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Submission: February 04, 2020; **Published:** February 24, 2020

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Abstract

Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder that causes deficits in motor learning and movement coordination. This affects posture, gross and fine motor skills, as well as the smooth running of activities of daily living. Children with DCD are more likely to adopt sedentary behaviors, and this negatively impacts their cardiovascular capacity, putting them at risk of developing metabolic diseases in adulthood. As an effective intervention to countermeasure these deleterious events, physical exercise is known to improve cardiovascular impairment. Several types of physical exercise such as aerobic exercise exist to help these children to improve their cardiovascular and motor capacities. However, when it comes to the evaluation of the cardiovascular capacity, it is often too difficult to accomplish the task leading to a loss of motivation during the test and giving a low accuracy to assess the results. The purpose of this mini review is to describe the exercise interventions and evaluation tools of the cardiovascular capacity in children with developmental coordination disorder.

Keywords: Physical activity; Aerobic capacity; Cardiovascular training; Developmental coordination disorders

Abbrevations: DCD: Developmental Coordination Disorder

Introduction

Developmental coordination disorder (DCD) is a neurodevelopmental disorder that causes deficits in motor learning and coordination of movement, in postural, fine and global motor skills [1]. Several motor deficits attenuating their postural control could persist from childhood to adolescence and even into adulthood [2]. These detrimental changes that significatively interfere with their daily activities [1-3], are not explained by the intellectual obstruction or other neurological condition that could affect motor function [1-3]. However, DCD is often associated with comorbidities such as attention deficit disorder, language disorders, autism spectrum disorder and dyslexia [1,2,4,5]. To countermeasure all the deleterious consequences that appears in children with DCD, physical activity could play an important role in this population. Nevertheless, a high percentage of these children have low levels of physical activity that is often characterized by a lack of motivation [1,2]. Unfortunately, their low levels of coordination and motor skills discourage them to engage in physical activities [2,6] such as free, sporting and recreational [7,8]. As a result of their low participation time in physical activities, few studies have shown that children with DCD are less active [9-11] and have more risk of obesity that increases with age [2,7,12]. This could explain the causes of arterial stiffness, the greater risk of developing cardiovascular diseases compared to their peers [7,12,13]. It is clearly stated in the literature that children with DCD have lower levels of cardiovascular fitness performance. Several studies using cardiovascular assessment tools such as VO2max, 20m anaerobic test and 6 minutes walking test (6MWT) have shown an inferior performance of children with DCD compared to their peers [3,4,14]. In a meta-analysis published by Rivilis et al. (2011) looking at 19 different studies with several measurements of cardiovascular capacity, 18 studies showed a significant lower level between children with DCD and their peers

[3]. However, few studies reported no differences between them. In fact, Ferguson et al. (2013) did not observe any differences during anaerobic performance between children with DCD and their peers [15]. In addition, Lay Chern Chia et al. (2013) also showed no significant differences in the oxygen cost of walking or running between young boys with or without DCD [16]. On the other hand, cardiovascular capacity assessment protocols do not seem to be adapted to the specific condition of children with DCD. The physical evaluation tools to assess the cardiovascular levels of this population seems to be very demanding to measure their actual condition. The evaluation is often too difficult and lead to a loss of motivation during the test giving a low accuracy to assess their cardiovascular capacity [6,10,17,18]. As the protocols of physical activities proposed in the framework of several studies are based on these evaluations, it is therefore very important to find optimal protocols to evaluate children with DCD. Thus, this would help health professionals to build interventions adapted to their condition. Hence, it is difficult to find enough evidence to support the recommendations such as the type, the duration and the evaluation of the cardiovascular exercise in children with DCD. The purpose of this mini review is to describe the exercise interventions and evaluation tools of the cardiovascular capacities in children with developmental coordination disorder.

Discussion

Effect of cardiovascular training on aerobic capacity in children with DCD

In the last 20 years, many researches were conducted to study the impact of the aerobic exercise on the cardiovascular capacity, the motor skills and the cognitive function in children with DCD. However, with the complexity and the various learning and behavioral difficulties stated in the introduction, it seems hard to have a consensus on the time, the type and the evaluation of the physical performance [19]. Considering the increasing prevalence of DCD and the negative impact affecting their activities of daily living, it is necessary to establish the different exercises modalities that seems to improve their quality of life [2]. In the following paragraph we will be discussing about the different type, modalities and time of interventions for children with DCD. Several studies focused on motor or sports exercise sessions [20,21], while others where more specific about the time of the intervention and the intensity of the cardiovascular exercise [22,23]. A study conducted by Tsai and al (2014) recruited twenty typically developing children and forty children with DCD, equally divided into DCD-training and DCD-nontraining groups. DCD-training group were asked to follow a 50-min session, 3 times a week for a total of 16 weeks. The endurance training program consisted of interval training, (repeated work-recovery bouts over short distance: 5×100m, 3×200m, 2×600m) one continuous long-distance running session, and one session with another aerobic activity (e.g., cycling, step aerobics, or rope jumping). The distance, speed, and number of repetitions were gradually increased throughout the training period according to each child's ability. Before and after the intervention, the PACER test, (a 20-m shuttle run test) was used to measure the cardiovascular performance. In the first minute, the initial running speed was set at 8.5 km/h, and this was then increased by 0.5km/h each subsequent minute. When a child failed to keep up with the pace by reaching the line at the time of the tone, the test was terminated at the second fault and the number of laps completed was recorded. Before the intervention, a significant difference was observed between DCD and TD children without any differences between DCD-training and DCD-non-training group. After the intervention, the DCD-training group increased significantly compared to baseline while the DCD-non-training group remained the same. However, the beneficial effect of the training in the DCD-training group did not attempt the level of cardiovascular performance of the TD group. This study showed a high percentage of adherence from all participants (99,47±0,69%). Another study led by Braaksma et al. (2018) used a complete fitness program for 10 weeks using a high intensity interval training (HIIT) running protocol. In this study, the intensity was based on the 80% of the predicted maximal heart rate measured during the 20meter Shuttle Run Test. The time intervals during the intervention were the same for all the participants but adjusted if needed to keep the intensity relative to each child. The results of the study are not published yet.

To our knowledge, there is only two studies that measured the actual intensity during the intervention by monitoring the number of steps [22] and the heart rate [24] during the intervention. These results have shown that this type of intervention is feasible and safe. Effect of motor skills exercises on cardiovascular capacity in children with DCD. The motor skills training programs are the most common intervention evaluated in children with DCD. Motor skill training without specific cardiovascular control parameters or intensity could also have beneficial impacts on cardiovascular fitness level [25]. The activities proposed often includes gross motor skills leading to improvement of the cardiovascular capacities (e.g. running, throwing, kicking, etc.). To our knowledge, no study measured the actual intensity or energy expenditure during the intervention. In fact, Farhat et al (2015) evaluated the aerobic power with indirect Vo2max measure on ergocycle in addition to the 6-min walking test (6MWT) in children with DCD (mean age 8y) [23]. The 8 weeks program (60min/session, 3 times a week) was consisted of a 10-min warm-up, 35-45min of skill and agility training, and 5min of recovery time. The program included motor abilities such as walking, running, climbing, and jumping. They focused on agility, strength, balance, flexibility, reaction speed and ball skills in the activities.

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The cardiovascular intensity in the session was however, not controlled. The results of the study showed that children with DCD improved significantly their maximal power output at anaerobic threshold and at peak level (maximal oxygen uptake). In addition, they found a better improvement in oxygen uptake (VO2: ml*/min^{-1}/kg^{-1}) at the anaerobic threshold (pre: 30.20±6.60 and post: 39.20±7.30) than the maximal intensity (pre: 40.12±5.76 and post: 46.47±7.86). Walking distance was also improved at the 6MWT (m) (pre: 573.10±65.80 and post: 864.60±45.20), they had a higher peak heart rate (beat/min) (pre: 130.00±24.60 and post: 148.40±13.70) and reduced perceived exertion. In addition to these cardiovascular benefits, children with DCD revealed a significant weight loss and improved their motor control [23]. Using a different approach to practice motor skills, Smits-Engelsman et al. (2017) used an Active Video Games Training Program in children with DCD [21]. Thirty-six children (18 DCD and 18 TD) were involved in a 5 weeks program practicing 2/week Nintendo Wii fit gaming for 20min/session. Every child got his own screen and has the possibility to choose the game he/she desire. All games were chosen in regards of their goals (target functional strength, anaerobic fitness, balance skills and agility). Before and after the intervention the anaerobic fitness (5x10 meter sprint test), the slalom sprint test (5x10 meter), the balance, running speed and Agility subtest of the Bruininks-Oseretsky were used to evaluate the physical condition of the participants. After the intervention, the results showed that the anaerobic performance significantly improved in both groups. The effect was more pronounced while children performed the sprint slalom test. The main effect of training was significant for both sprint tests while no interaction with groups was found. In addition, at the end of the intervention, all children ran the slalom track 30% faster than baseline. Children with DCD improved significantly their balance without any differences seen in TD group. The general results of these studies showed that any type of physical intervention has a positive impact on cardiovascular capacity in children with DCD. However, another important component that could affect the cardiovascular parameters is the psychological state of the child. Thus, Silman et al. (2011) showed that perceived adequacy and physical activity were significant mediators in the relationship between children with DCD and VO2peak (R-squared = 24.3%) [26]. This study verifies that low aerobic power is one of the most important components of cardiorespiratory fitness, related to health consequences associated with DCD. When it comes to the explanation behind these differences, one of the very first researchers questioning the low values observed in aerobic performance in children with DCD when compared to their peers is Cairney et al in 2006. In his study, a large sample of children (n=586) were examined using the 20-m shuttle run test [27]. They measured the perceived adequacy using a 7-item factor from the Children's Self-perception of Adequacy in and Predilection for Physical Activity (CSAPPA). The results of the study showed no differences in Vo2max between the two groups. However, the CSAPPA questionnaire revealed that children with DCD have significantly lower scores. This can be explained by the fact that children with DCD may give up sooner because they believe they are simply not as good at physical tasks as other children. After this publication, many other researchers confirmed these theories showing that the lack of motivation and the low self-esteem when compared to others may have an influence on the cardiovascular capacity [3,8,28,29].

Limiting factors influencing cardiovascular assessments tools in children with DCD

Cardiovascular assessment protocols and energy expenditure are often measured by numerous tools with different degrees of precision. Many validated cardiovascular tests and instruments are used to measure the cardiovascular fitness level of children with DCD. For example, the direct VO2peak using an ergocycle [26,28], the shuttle run test [7,11,17,30-32], the incremental treadmill protocol [16,33], 6-min run test [34], 6 min walk test [35] and half-mile run [36], were used to investigated cardiovascular capacity. The measures of anaerobic power typically included short maximal running distance such as a 50-yard sprint [17,30], 600-yard run [30] or the muscle power sprint test [32]. However, several tools to assess the cardiovascular fitness level of this population seems to be very demanding to measure their actual condition. Indeed, few studies showed that cardiovascular assessment protocols in children with DCD have various limitations [3,6,17,18,26]. The evaluation is often too difficult and lead to a loss of motivation during the test giving a low accuracy to assess precisely their actual cardiovascular condition. In fact, the motor coordination deficiency of children with DCD could have a negative impact during the cardiovascular evaluation. A study using the Léger shuttle run, found that children with motor learning difficulties ran significantly fewer laps during the test by 27% [37]. As mentioned previously in the study published by Cairney et al. (2008), one-third of the children with DCD showed lower scores on perceived adequacy assessed using the Children's Self-perception of Adequacy and Predilection for Physical Activity scale [38]. Several studies supported these results showing that the perceived adequacy was a significant mediator in the relationship between adolescent with DCD (12-13 years of age) and VO2peak [26]. It is well known that children with DCD have also poor perceive self-capacities in physical activities [2,6,8]. Thus, this factor could limit not only the cardiovascular assessment but also the intensity exerted by the children with DCD during cardiovascular training compared to their real capacities. The children withdrew the test possibly because they perceived the task to be difficult [14,16]. Adding to these inner parameters, motivation is another point stated in several studies.

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As mentioned previously, the motivation to engage in physical activities is significantly lower in children with DCD compared to their peers [3,8,39]. The results during the aerobic assessment and the cardiovascular training could be explained by the lack of motivation in children with DCD [14,16,40]. The psychological state is therefore an important factor to consider in this population for results interpretation as well as cardiovascular assessment and training. As report by Rivilis et al. (2011), an enormous part of their real performance during a cardiovascular evaluation relies on their intrinsic motivation [3]. This is particularly challenging for children with DCD because, they generally have poor perceived self-competence and have less motivation to participated in various type of motor activities [8,26]. Thus, the maximal intensity and the assessment required by the cardiovascular evaluation could lead to a potential dropping out prematurely showing an underestimated result of their actual aerobic capacity [3,26,27]. The authors also highlighted the importance of adequate motivational encouragement from the professional assessing the test in order to assist the child to achieve maximum effort. In summary, all the limits discussed in this paragraph shows that cardiovascular assessment tools in children with DCD needs a better consensus helping health professionals to better estimate the Vo2max and other aerobic parameters in this population.

Conclusion

In conclusion, cardiovascular fitness level in children with DCD seems to play a very important role in the general health of this population. In addition, physical activity has even an impact on their enjoyment and self-esteem. However, it is very important to set more accurate cardiovascular evaluation leading to a better understanding of their actual fitness capacity. Using these variables, health professional will be able to set interventions more adapted to their condition. Most of the studies showed the importance of self-esteem and encouragement during these evaluations especially with children with DCD to maximize their aerobic capacity leading a better precision in future results.

Acknowledgment

The authors thank the Université du Québec à Montréal for the financial support in the writing of this review. The sponsor had no role in the writing of the manuscript and in the decision to submit the manuscript for publication.

Conflict of interest

All authors declare no conflicts of interest and approve the final submission.

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