EXPLORING PHYSICAL LITERACY, PHYSICAL ACTIVITY LEVELS, AND CARDIORESPIRATORY FITNESS IN CHILDREN AT RISK FOR MOVEMENT DIFFICULTIES: A COMPARATIVE STUDY

Lydia Stagianni[1], Vasiliki Kaioglou[1], Apostolos Stagiannis[2], Thomas Kourtessis[3], Antonis Kambas[4], and Fotini Venetsanou[1]

[1]School of Physical Education and Sport Science, National and Kapodistrian University of Athens, Athens, Greece
[2]12th Primary School of Neo Irakleio, Athens, Greece
[3]Department of Early Childhood Education & Care, International Hellenic University, Thessaloniki, Greece
[4]Department of Physical Education and Sport Science, Democritus University of Thrace, Komotini, Greece

Original scientific paper
DOI 10.26582/k.57.2.3

Abstract:

A significant percentage of school-aged children experience movement difficulties that negatively affect various aspects of their daily lives. This study aimed to examine perceived physical literacy, physical activity, and cardiorespiratory fitness of children at risk for movement difficulties and compare these parameters with their typically developing peers. Ninety-seven children, aged 11-12 years (M=11.57±0.49 years) participated voluntarily. The Movement Assessment Battery for Children Checklist-2 was used to identify children at risk for movement difficulties. The 20-meter shuttle run test, the Physical Activity Questionnaire for Children, and the Physical Literacy for Children-Questionnaire were used to assess cardiorespiratory fitness, physical activity, and physical literacy, respectively. Results revealed that 16.5% of the participants were at risk for movement difficulties, while 15.5% had poor motor competence. These children demonstrated statistically significant lower levels of physical activity, cardiorespiratory fitness, and perceived physical literacy (particularly in physical and psychological domains) compared to their typically developing peers. The findings highlight the significant role of motor competence in perceived physical literacy, physical activity, and cardiorespiratory fitness and underscore the need for timely identification of possible motor competence deficits and implementation of specifically tailored movement programs aiming at children's holistic development.

Keywords: *motor competence, perceived physical literacy, Physical Activity Questionnaire for Children, Physical Literacy for Children-Questionnaire*

Introduction

Motor competence (MC) is widely recognized as a key factor in supporting children's physical activity (PA) participation (Robinson, et al., 2015), even in the long-term (Lloyd, Saunders, Bremer, & Tremblay, 2014; Venetsanou & Kambas, 2017). However, not all children develop typical levels of MC. Some children, despite having sufficient general intelligence, struggle to coordinate their movements to perform movement tasks according to their age (Mandich, Polatajko, & Rodger, 2003), due to motor coordination difficulties that diminish their possibilities to successfully engage in PA and sport. According to the American Psychiatric Association (2013), 5-7% of the total school population has developmental coordination disorder (DCD), with boys facing movement difficulties more often (Sankar & Monisha, 2019).

Not only children with DCD, but also those facing movement difficulties (MD) present lower levels of PA compared to their typically developing peers (Baniasadi, Khajeaflaton Mofrad, & ShafaeianFard, 2022; Cairney, Veldhuizen, King-Dowling, Faught, & Hay, 2017; Li, Kwan, King-

Dowling, Rodriguez, & Cairney, 2021; Wright, et al., 2019). This is concerning, since PA has been well manifested that has a positive impact on children's overall health and development (Chaput, et al., 2020; Ghorbani, Afshari, Eckelt, Dana, & Bund, 2021). Unfortunately, given the suggested reciprocal relationship between MC and PA (Britton, Issartel, Symonds, & Belton, 2020; Jaakkola, et al., 2019), children with MD seem to face a vicious circle of disengagement from PA. Further insight into the problematic engagement of children with MD reveals that, in addition to their actual MC deficits, their motivation for being active is similarly low (Brown, Dudley, & Cairney, 2020; Purcell, Schott, Rapos, Zwicker, & Wilmut, 2023). This is linked to their poor self-confidence (Noordstar & Volman, 2020; Yu, et al., 2016;) and perceived ability to perform in sports and PA (Baniasadi, et al., 2022; St. John, Dudley, & Cairney, 2021).

In addition to facing challenges in their PA participation, children with MD often exhibit low levels of physical fitness compared to their peers (Chagas & Batista, 2017; Farhat, et al., 2015; Klavina, Ostrovska, & Campa, 2017). This is not unexpected, since there is an established positive association between MC and physical fitness in children (Barnett, Mazzoli, Bowe, Lander, & Salmon, 2022; Utesch, Bardid, Büsch, & Strauss, 2019), with cardiorespiratory fitness (CRF) presenting the strongest association with children's MC (Behan, Belton, Peers, O'Connor, & Issartel, 2022). Several studies confirm that CRF is closely associated with MC and that this relationship is reciprocal and longitudinal during childhood and adolescence (Lima, Bugge, Ersbøll, Stodden, & Andersen, 2019). These findings suggest that the development of CRF in children with MD should not be underestimated, specifically given that CRF also relates to PA (Eberline, Judge, Walsh, & Hensley, 2018; Kjellenberg, Ekblom, Stålman, Helgadóttir, & Nyberg, 2021). In this context, the low CRF levels observed in children with MD (Cairney, et al., 2017; Farhat, et al., 2014; Faught, et al., 2013; Sujatha, Alagesan, Seemathan, & Sadhasivam, 2020; Van der Hoek, et al., 2012) are concerning, as they may further restrict these children's ability to cope with aerobic challenges and, consequently, limit their opportunities to engage successfully in PA.

Considering the above, it becomes clear that promoting PA in children with MD requires a holistic approach that takes into account its intercorrelations with the constructs mentioned above. Such an approach aligns with the concept of physical literacy (PL), which is recently recognized as an important requirement for healthy active living and holistic development (Whitehead, 2019). According to the widely recognized definition of the International Physical Literacy Association (2017), PL is a disposition identified in every human, regardless of their physical condition or capabilities and it can be described as motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life. Embracing the above definition of PL, the Canadian Consensus Statement recognizes PL as multidimensional construct consisting of four intercorrelated PL domains, i.e., Motivation and confidence (Affective), Physical competence (Physical), Knowledge and understanding (Cognitive), and Engagement in PA for life (Behavioural) (Tremblay, et al., 2018a). However, definitions of PL may vary around the world to reflect cultural and/or organizational differences (Shearer, et al., 2018), researchers agree that developing PL in childhood is essential for fostering healthy and active habits that can follow them into adulthood (Castelli, Barcelona, & Bryant, 2015; Whitehead & Almond, 2013).

Despite the growing recognition of PL's importance, research has shown that typically developing children worldwide are not sufficiently physically literate (Kaioglou, Dania, & Venetsanou, 2020; Li, et al., 2020; Tremblay, et al., 2018b). This raises significant concerns about the PL of children with MD, who seem to be at a disadvantage in terms of PA, physical fitness, and perceived competence. A critical review of conventional practice specifically in the field of DCD reveals that the framework of PL, although considered a potentially feasible framework for assessment and intervention, has not been utilized accordingly (Miyahara, 2020). So far, researchers have primarily focused on typically developing children, leaving an important gap regarding the PL of children with MD (with or without DCD). Since assessment is the first and essential step in designing effective interventions (Miyahara, 2020; Shahzad, & Jameel, 2022), addressing this gap is important. This study extends previous international work by examining the perceived PL of children with MD, as well as key components of PL, such as PA participation and CRF, in comparison with typically developing children.

Methods

Participants

The study involved a convenience sample consisting of 97 children (50 boys and 47 girls) aged 11-12 years (11.57 $\pm$ 0.49 years), all of whom were in the 5th and 6th grade at two primary schools in Athens, Greece. Inclusion criteria were: (a) children aged 11-12 years enrolled in 5th or 6th grade at the participating schools, (b) sufficient language/cognitive ability to fill in the questionnaires of the study. Exclusion criteria were: (a) lack of consent/assent, (b) presence of any conditions that would prevent participation in the CRF assessment.

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Prior to data collection, approval was obtained from the school directors, who were informed about the purpose and procedures of the study. Assent was secured from the children, and written informed consent was obtained from their parents/legal guardians. Participation was voluntary, and participants retained the right to withdraw from the study at any time without any consequences. All data were treated confidentially and used solely for research purposes. The study was approved by the Ethics committee of the School of Physical Education and Sport Science, National and Kapodistrian University of Athens, Greece (1330/17-11-2021).

Measures

Movement difficulties

The MABC-2 Checklist (MABCC-2; Henderson, Sugden, & Barnett, 2007) was used in the current study to identify children at risk for MD. The MABCC-2 is specifically developed for this kind of identification, and it is designed for use mainly for elementary school-aged children (i.e., age range from 5 to 12 years). It comprises a motor and a non-motor part. Each part consists of 30 items, covering a wide range of specific motor behaviors which can be observed in a child's motor daily life, and grouped in two sections (Section A=static and/or predictable environment and Section B=moving and/or unpredictable environment). A 4-point scale (0=very well; 3=not close) is being used for scoring the MABCC-2. The Total Motor Score derives from the sum of the 30 items, with high scores representing poor performance.

In this study, the Greek Version of the MABCC-2 was used. The psychometric characteristics of this version are sufficiently supported by several studies (Dimitropoulou et. al., 2009; Kourtessis, et al., 2008). The MABCC-2 was administered by the physical education teacher who taught at both participating schools. Prior to data collection, the physical education teacher received a printed copy of the checklist manual and subsequently completed a 90-minute training session led by the research team. This session included clarification of questions arising from the manual, scoring examples, and supervised scoring of pilot cases. Data collection commenced once consensus was reached between the physical education teacher and the trainer regarding the scoring of students' motor competence.

For the interpretation of the Total Motor Score of the MABCC-2 a "traffic light system" is being used, showing whether the child falls into the typical range for their age (green zone), shows mild MD (amber zone) or has severe motor difficulties (red zone) (Henderson, et al., 2007). However, taking into account low rates of either sensitivity or specificity of the questionnaires used to assess MD (Faught, et al., 2008; Schoemaker, et al., 2006; Schoemaker, Niemeijer, Flapper, & Smits-Engelsman, 2012), in the current study, the "traffic light system" was interpreted more conservatively, with scores falling into the red zone indicating "at risk for MD" and those falling into the amber zone indicating "poor MC".

Cardiorespiratory fitness

Participants' CRF was assessed using the 20m shuttle run test (Meredith & Welk, 2010). In this test, children are asked to run continuously back and forth between two lines spaced 20 meters apart, following audio signals from a sound playback device and try to complete as many laps as possible while keeping pace with the audio signals. The audio signals gradually increase in frequency at each stage, requiring participants to run faster as the test processes. Each successful traversal of the distance between the two lines is counted as one lap. The test is terminated when the participant fails to reach the 20 m line on two consecutive occasions or voluntarily stops due to exhaustion. Children's score is the total number of laps completed.

Physical activity

Participants' PA was measured with the Physical Activity Questionnaire for Children (PAQ-C; Kowalski, Crocker, & Donen, 2004), a validated tool designed to assess PA in children over the past seven days (Kowalski, Crocker, & Faulkner, 1997). The PAQ-C consists of ten items that explore various aspects of a child's PA, including the frequency, the types of activities, as well as possible reasons that may lead children to refrain from engaging in PA. Each of the first nine items is scored on a scale from 1 to 5 (1= low PA, 5= high PA), while the tenth item is not included in the final score. The overall score is derived by averaging the scores from items 1-9. In this study, the Greek version of the PAQ-C, which psychometrics were adequately supported (Venetsanou, et al., 2020) was utilized. Cronbach's alpha for the current sample was .82, indicating good internal consistency of the questionnaire.

Physical literacy

The Greek version (PL-C Quest [Greek]; Kaioglou, et al., 2025) of the Physical Literacy in Children Questionnaire (PL-C Quest; Barnett, et al., 2020) was employed to assess children's perceived PL. The PL-C Quest is designed to assess how children aged 4-12 perceive their own PL, encompassing four main domains: motor, mental, cognitive, and social. It consists of 30 items, each rated on a scale from one to four, with four indicating the highest level of perceived PL. Total PL score is calculated by summing the 30 items' scores. The PL-C Quest (Greek) is a valid and reliable scale for Greek children 4-12 years of age, showing good internal consistency (α = .83), as well as good test-retest reliability (ICC = .87) (Kaioglou, et al., 2025). In the current study, Cronbach's alpha was found to be .84, indicating good internal consistency.

Procedure

Data collection was conducted within school premises during physical education classes over two months (February and March 2023). Firstly, the MABCC-2 was administered by the physical education teacher. Secondly, the PAQ-C and the PL-C Quest (Greek) were administered collectively to each class. Each questionnaire was completed within one physical education class period. Thirdly, the 20-meter shuttle run test was conducted during an additional physical education class period. Participants' data were collected, stored, and analyzed anonymously. No personal identifiers were recorded at any stage of the research procedure. Unique codes were assigned to participants' responses to ensure confidentiality and anonymity. Electronic data were stored on secure, password-protected devices, and access was restricted to members of the research team.

Data analysis

Initially, descriptive statistics, including means, standard deviations, and frequencies, were calculated for the demographic characteristics of the participants, as well as for the key variables of interest. Preliminary analyses included: (a) independent sample t-tests to explore potential gender differences in PA, PL, and CRF, and (b) a correlation analysis to examine the relationship between children's age with their PL, PA, and CRF. Then, to examine potential differences between children at risk for MD, children with poor MC, and typically developing children, we performed: (a) univariate analyses of variance (ANOVAs) on children's total PAQ-C scores and PL-C Quest (Greek) scores, (b) a multivariate analysis (MANOVA) on the four PL-C Quest (Greek) domains, and (c) a univariate analysis of covariance (ANCOVA) on children's CRF scores (due to the statistical significant association of children's gender with CRF scores found in preliminary analyses). Before performing the above analyses, the data were checked for compliance with the assumptions of the analyses (outliers, multivariate normality, homogeneity of variance, homogeneity of covariance matrices).

A significance level of $p<.05$ was set as the threshold for statistical significance. For pairwise comparisons the Bonferroni multiple comparison test was performed. Beyond statistical significance, the practical significance of differences was also assessed using the eta squared (η^2) statistic, with η^2 values greater than .14 indicating practically significant differences as suggested by Cohen (1988).

Results

Children's MC assessment with the M-ABCC-2 revealed that 15.5% of children had poor MC and 16.5% were at risk for MD. When analyzed by gender, it was found that 24% of boys had poor MC and 16% were at risk for MD. In contrast, 6.4% of girls had poor MC and 17% were at risk for MD. Table 1 provides a detailed breakdown of descriptive statistics for the three groups (typically developing, poor MC, at risk for MD) across the key variables (i.e., PL, PA, and CRF).

Preliminary analyses indicated that participants' age was not significantly correlated with any of the key variables ($p>.05$). Additionally, no significant gender differences were identified in PL or PA ($p>.05$), whereas in the 20-meter shuttle run test, boys outperformed girls (25.92 $\pm$ 11.53 laps vs. 19.08 $\pm$ 8.92 laps; $p<.001$). Thus, gender was controlled for in the subsequent analyses that explored associations between MC and CRF.

Starting with PA, the ANOVA revealed a statistically and practically significant association of MC

Table 1. Descriptive statistics (means±standard deviations) for physical literacy, physical activity, and cardiorespiratory fitness by MC group

	Typically developing	With poor MC	At risk for MD
PL-C Quest			
Physical domain	40.14±4.05	35.67±6.09	32.88±6.61
Psychological domain	23.86±2.87	23.13±3.91	21.50±3.33
Social domain	13.70±1.98	13.47±2.59	12.94±2.24
Cognitive domain	23.92±2.86	22.67±3.60	22.44±3.58
Total score	101.62±8.89	94.93±11.60	89.75±12.95
PAQ-C total score	3.18±0.55	2.77±0.51	2.34±0.62
20-m shuttle run test (laps)	25.28±10.70	19.00±7.04	15.13±10.72

Note. MC = motor competence, MD = movement difficulties PAQ-C=Physical Activity Questionnaire for children, PL-C Quest = Physical Literacy for Children-Questionnaire, Physical domain = 12-48 points, Psychological domain = 7-28 points, Social domain = 4-16 points, Cognitive domain = 7-28 points, Total score = 30-120 with the PAQ-C scores (F=16.16, p<.001, η^2=.26). Typically developing children had significantly higher PAQ-C scores than those with poor MC (Mean Difference= .41, p=.034) and at risk for MC (Mean Difference= .84, p<.001).

Significant differences were also observed in PL-C Quest (Greek) total scores (F=10.13, p<.001, η^2=.18), with typically developing children outperforming only those at risk for MD (Mean Difference=11.87, p<.001). The MANOVA applied to the four domains of the PL-C Quest showed that MC was a significant factor (Pillai's trace = .28, F = 3.78, p<.001, η^2 =.141). Follow-up ANOVAs identified significant differences in the physical domain (F=16.72, p<.001, η^2=.26), where typically developing children had higher scores than those with poor MC (Mean Difference= 4.47, p=.006) and at risk for MD (Mean difference= 7.26, p<.001). There were also statistically significant differences in the psychological domain (F=3.75, p=.027, η^2=.07), with typically developing children outperforming only those at risk for MD (Mean difference= 2.36, p=.023). However, no significant differences were found in the social (F= .83, p=.44, η^2=.02) or cognitive (F=2.09, p=.13, η^2=.04) domains.

After controlling for gender (F=18.07, p<.001, η^2=.17), the ANCOVA revealed statistically and practically significant differences in CRF between the groups (F=11.24, p<.001, η^2=.20). Typically developing children outperformed those with poor MC (Mean difference= 9.14, p= .004) and those at risk for MD (Mean difference= 10.75, p=.001). Across all the abovementioned analyses, no statistically significant differences were found between children with poor MC and those at risk for MD. Summary of the significant differences found in this study is visually presented in Figure 1.

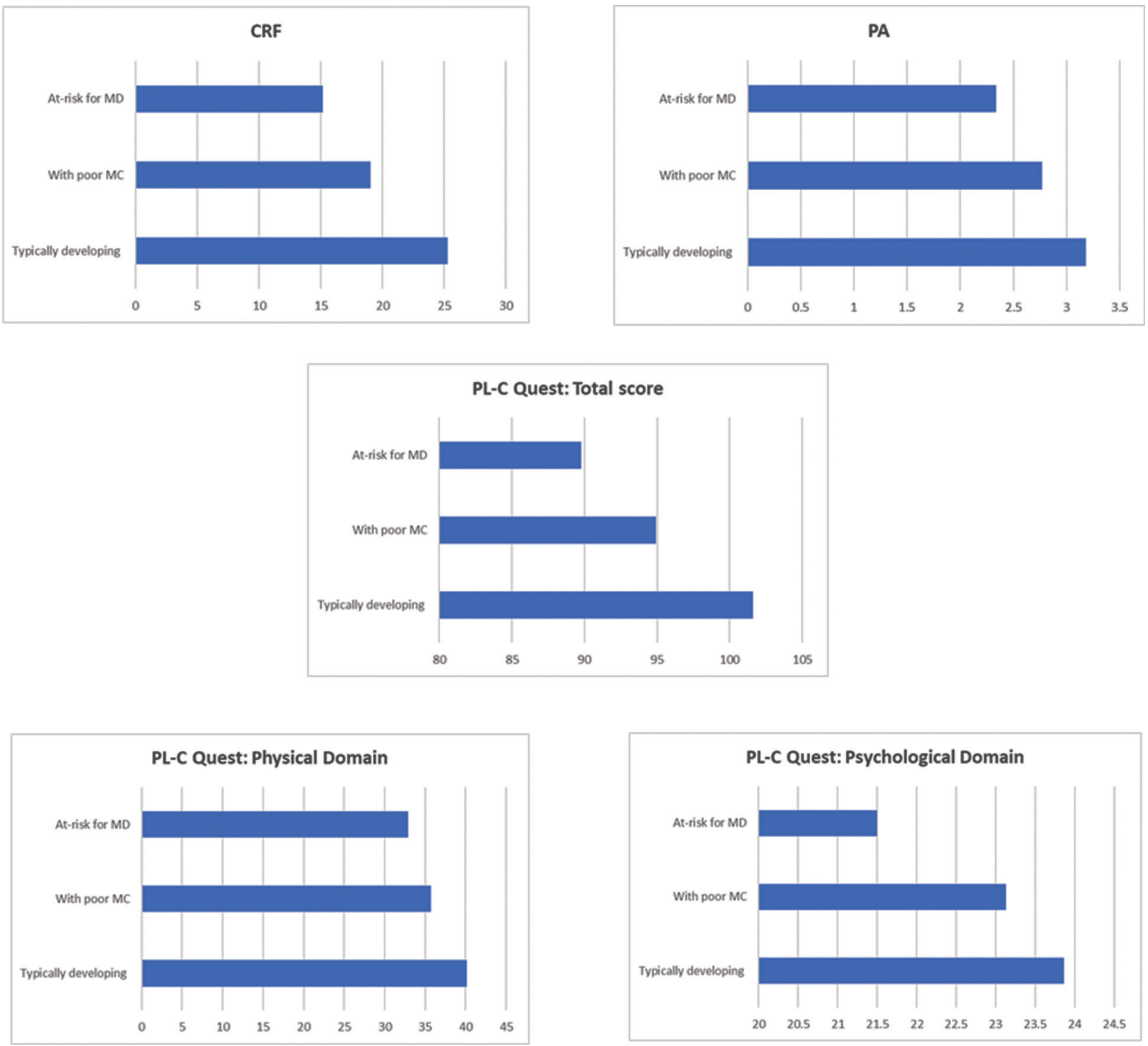

Figure 1. Significant group differences.

Discussion and conclusions

A significant percentage of school-aged children face MD, which negatively affects various aspects of their lives. However, currently, there is a lack of studies addressing potential deficits of these children in constructs related to their health and development as well as their overall potential to build an active lifestyle, such as PA, CRF, and PL. This is the first cross-sectional study to investigate the profile of children at risk for MD in terms of their PA, CRF, and perceived PL. Comparisons with typically developing peers revealed that not only children at risk for MD but also those with poor MC exhibited lower levels of PA, CRF, and perceived PL.

Starting with children at risk for MD, who were the primary focus of this study, our results showed that they had low levels of PA. This finding supports the hypothesized association between impairments in children's MC and reduced participation in PA, confirming previous studies (e.g., Baniasadi, et al., 2022; Li et al., 2021; Wright, et al., 2019). Additionally, these children exhibited lower CRF levels—a common finding in similar studies (Cairney, et al., 2017; Sujatha, et al., 2020). These findings raise concerns about the extent to which the diminished physical competence (i.e., MC and physical fitness) affects children's engagement in PA. The mediating role of CRF in the bidirectional relationship between MC and PA (Kaioglou, Dania, Kambas, & Venetsanou, 2023) explains why an adequate physical competence level is crucial for engagement in PA and why the latter condition is similarly important for enabling the refinement of children's physical abilities.

Children at risk for MD also reported poor levels of perceived PL, particularly in terms of their perceived physical abilities (physical competence domain) and their attitudes and emotions that impact movement (psychological domain). Given their low levels of PA and CRF, it is not surprising that these children also had low perceptions of their overall PL. By late childhood, children are expected to develop more accurate perceptions of their physical competence (Field, Crane, Naylor, & Temple, 2020); thus, it is likely that children at risk for MD in this study were able to realize their lower level of physical abilities. It is well documented that children with MD often demonstrate low motivation (Dunford, Missiuna, Street, & Sibert, 2005; Katartzi, & Vlachopoulos, 2011; Lopes, Rodrigues, Maia, & Malina, 2011) and poor self-confidence (Cocks, Barton, & Donelly, 2009; Poulsen, Ziviani, & Cuskelly, 2008). These psychological deficits are not independent of the low actual and perceived physical competence that children at risk for MD presented in this study. Researchers argue that the inability to perform movement skills leads to a psychological disadvantage, which manifests as low motivation and self-confidence (Cocks, et al., 2009; Katartzi & Vlachopoulos, 2011; Lopes, et al., 2011; Poulsen, et al., 2008). This is linked with the fear of failure and the subsequent lower enjoyment in PA. Moreover, PA's environment is not always appropriate for all participants. Limited access to inclusive physical education and insufficient equipment are important factors that can lead to lower PL in children with MD (Hebinck, Pelletier, Labbé, Best, & Robert, 2023). Lower motivation and self-confidence are also influenced by psychosocial factors, such as social exclusion, comparison with peers and bullying (Cairney, Dudley, Kwan, Bulten, & Kriellaars, 2019). Therefore, PL levels are not only related to motor skills in children with MD, but also to psychological, environmental and psychosocial factors.

Our findings are particularly concerning because, according to several reports, even typically developing children do not demonstrate adequate levels of actual PL in Greece (Kaioglou, et al., 2020) and elsewhere (Li, et al., 2020; Tremblay et al., 2018b). This situation is alarming, since recent literature findings indicate that there are bidirectional relationships between PL level with both PA participation (Li, Sum, Sit, Liu, & Li, 2021) and physical competence (Mengyu, Yuxing, Ziqing, Lizhu, & Lili, 2025) in typically developing children. These findings suggest a positive feedback loop in which each construct supports and amplifies the others, emphasizing the importance of early interventions to promote all three domains concurrently.

Interestingly, not only did children falling into the "red zone" of the MABCC-2 "traffic light system" exhibited lower PA, CRF, and PL levels. Those in the "amber zone" presented similar values to their peers at risk for MD. These results confirm the vicious circle of disengagement from PA for children presenting an insufficient level of MC. The interdependence between actual physical competence, perceived physical competence, and PA participation has been well described in theoretical models of lifelong PA (Stodden, et al., 2008). Accordingly, the low levels of actual and perceived physical competence, which are partly explained by children's limited PA/sporting experiences, may further undermine their potential to participate in sustainable PA.

At this point, the high percentage of children classified into the "amber" and the "red" zones of the MABCC-2 in the current study should be noticed, because it is certainly not "good news". These findings along with previous ones disclosing high rates of Greek children presenting MD (Ellinoudis, Kourtessis, Kiparissis, & Papalexopoulou, 2008; Kourtessis, Tzetzis, Kioumourtzoglou, & Mavromatis, 2001), open the discussion about the potential reasons causing this unfavorable situation. One possible explanation is that Greek children recently adopt sedentary behaviors (Venetsanou, Kambas, Gourgoulis, & Yannakoulia, 2019), which limit their chances to engage in active situations and thus, result in serious interruptions in skill development (Tsiotra, et al., 2006). Even though sedentary behavior was not examined in this study, it is possible that these children indeed lead sedentary lifestyles. This pattern underscores the importance of early and coordinated action within Greece's educational and public health systems. Integrating MC and PL assessments into school curricula could support early detection of at-risk children, while national policies—such as the implementation of daily PA programs and the enhancement of teacher training in movement education—could help counteract sedentary behaviors and promote lifelong engagement in PA. Unfortunately, at present, such coordinated actions remain limited and insufficiently effective in this direction.

Taking into account the critical role of PA for health and development (Chaput, et al., 2020; Ghorbani, et al., 2021; Poitras, et al., 2016), children with poor MC and/or MD appear to be a population under risk. It is obvious that any potential deficits in MC, CRF, and PL should be timely addressed with movement programs incorporating children's unique skills, characteristics, and needs. In this context, the holistic philosophy of PL provides a feasible framework for early diagnosis of probable MD and a framework for designing and implementing interventions. These interventions focus on purposefully improving the motor domain through practices/tasks that emphasize personalized learning tailored to children's skills, characteristics, needs, and interests (Miyahara, 2020). Interventions that comply with PL philosophy aim at developing children's MC (in a wide range of motor skills) holistically by inducing improvements in the affective, cognitive and behavioral domain too (Whitehead, Durden-Myers, & Pot, 2018; Whitehead, 2013). In such a context, personal accomplishments should only be compared with one's previous accomplishments, while they can occur in a safe and supportive environment. In such an environment, each child feels free to make their best effort, challenging their own skills and practicing for an adequate amount of time under the guidance of experienced professionals which offers them constructive feedback. Accordingly, motor learning is an enjoyable and, overall, a positive experience that has the potential to fulfil children's fundamental psychological need for competence and success.

Overall, the findings of the present study have important implications for educators, therapists, and policymakers. Given that children at risk for MD and those with poor MC exhibit low levels of PA, fitness, and perceived PL, educational and therapeutic practices should emphasize early detection and tailored movement interventions. Educators can foster inclusive environments that promote confidence, enjoyment, and skill development, while therapists can design individualized programs addressing both motor and psychosocial aspects of movement. Policymakers play a crucial role in supporting such efforts through early screening initiatives, professional training, and policies that ensure equitable access to quality PA opportunities for all children.

As previously reported, this study is the first attempt to examine PA, CRF, and perceived PL in children at risk for MD, a field that remains unexplored. However, this study has certain limitations that should be considered when interpreting its results. While a field test was used to assess CRF, children's PA and PL were self-reported, albeit using valid and reliable tools. Additionally, participants' MC was assessed with a checklist, which may have resulted in a higher percentage of children being identified at risk for MD. That is why we interpreted the "traffic light system" conservatively. Moreover, the study's cross-sectional design does not allow for causal inferences.

Future research employing longitudinal designs will help track changes over time. Lastly, beyond the constructs examined in this study, other potential factors influencing both motor development and the adoption of an active, healthy lifestyle should also be explored. Future research should focus on unveiling these factors and prioritize the development of holistic programs targeting the overall development of children with MD and/or poor MC.

Summarizing the aforesaid, children at risk for MD and those with poor MC exhibited significantly lower levels of PA, CRF, and perceived PL, in comparison with their typically developing peers. Specifically, regarding PL, these children specifically presented lower perceived physical competence and poorer attitudes and emotions related to movement. These findings highlight the significant role of these constructs in enhancing children's holistic development and underscore the need for timely identification of possible MC deficits and the implementation of tailored movement programs aiming at children's holistic development.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). American Psychiatric Publishing.

Baniasadi, T., Khajeaflaton Mofrad, S., & ShafaeianFard, F. (2022). Associations between physical activity with self-esteem and perceived motor competence among children with developmental coordination disorder. *Journal of Modern Psychology*, *2*(2), 1-10. https://doi.org/10.22034/jmp.2022.357946.1038

Barnett, L.M., Mazzoli, E., Bowe, S.J., Lander, N., & Salmon, J. (2022). Reliability and validity of the PL-C Quest, a scale designed to assess children's self-reported physical literacy. *Psychology of Sport and Exercise*, *60*, 102164. https://doi.org/10.1016/j.psychsport.2022.102164

Barnett, L.M., Mazzoli, E., Hawkins, M., Lander, N., Lubans, D.R., Caldwell, S., …, & Salmon, J. (2020). Development of a self-report scale to assess children's perceived physical literacy. *Physical Education and Sport Pedagogy*, *27*(1), 91-116. https://doi.org/10.1080/17408989.2020.1849596

Behan, S., Belton, S., Peers, C., O'Connor, N.E., & Issartel, J. (2022). Exploring the relationships between fundamental movement skills and health related fitness components in children. *European Journal of Sport Science, 22*(2), 171-181. https://doi.org/10.1080/17461391.2020.1847201

Britton, U., Issartel, J., Symonds, J., & Belton, S. (2020). What keeps them physically active? Predicting physical activity, motor competence, health-related fitness, and perceived competence in Irish adolescents after the transition from primary to second-level school. *International Journal of Environmental Research and Public Health*, *17*(8), 2874. https://doi.org/10.3390/ijerph17082874

Brown, D.M., Dudley, D.A., & Cairney, J. (2020). Physical literacy profiles are associated with differences in children's physical activity participation: A latent profile analysis approach. *Journal of Science and Medicine in Sport*, *23*(11), 1062-1067. https://doi.org/10.1016/j.jsams.2020.05.007

Cairney, J., Dudley, D., Kwan, M., Bulten, R., & Kriellaars, D. (2019). Physical literacy, physical activity and health: Toward an evidence-informed conceptual model. *Sports Medicine*, *49*(3), 371-383. https://doi.org/10.1007/s40279-019-01063-3

Cairney, J., Veldhuizen, S., King-Dowling, S., Faught, B.E., & Hay, J. (2017). Tracking cardiorespiratory fitness and physical activity in children with and without motor coordination problems. *Journal of Science and Medicine in Sport*, *20*(4), 380-385. https://doi.org/10.1016/j.jsams.2016.08.025

Castelli, D.M., Barcelona, J.M., & Bryant, L. (2015). Contextualizing physical literacy in the school environment: The challenges. *Journal of Sport and Health Science*, *4*(2), 156-163. https://doi.org/10.1016/j.jshs.2015.04.003

Chagas, D.V., & Batista, L.A. (2017). Comparison of health outcomes among children with different levels of motor competence. *Human Movement*, *18*(2), 56-61. https://doi.org/10.1515/humo-2017-0018

Chaput, J.P., Willumsen, J., Bull, F., Chou, R., Ekelund, U., Firth, J., …, & Katzmarzyk, P.T. (2020). 2020 WHO guidelines on physical activity and sedentary behavior for children and adolescents aged 5–17 years: Summary of the evidence. *International Journal of Behavioral Nutrition and Physical Activity*, *17*, 141. https://doi.org/10.1186/s12966-020-01037-z

Cocks, N., Barton, B., & Donelly, M. (2009). Self-concept of boys with developmental coordination disorder. *Physical and Occupational Therapy in Pediatrics*, *29*, 6-22. https://doi.org/10.1080/01942630802574932

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). New York, NY: Academic Press.

Dimitropoulou, D., Kourtessis, T., Tsigilis, N., Mouratidou, A., Ellinoudis, T., & Evangelinou, C. (2019). Concurrent validity of the movement assessment battery for Children Checklist-2. *European Psychomotricity Journal*, *11*(1), 19-38.

Dunford, C., Missiuna, C., Street, E., & Sibert, J. (2005). Children's perceptions of the impact of developmental coordination disorder on activities of daily living. *British Journal of Occupational Therapy*, *68*(5), 207-214. https://doi.org/10.1177/030802260506800504

Eberline, A., Judge, L.W., Walsh, A., & Hensley, L.D. (2018). Relationship of enjoyment, perceived competence, and cardiorespiratory fitness to physical activity levels of elementary school children. *Physical Educator*, *75*(3), 394-413. https://doi.org/10.18666/TPE-2018-V75-I3-8161

Ellinoudis, T., Kourtessis, T., Kiparissis, M., & Papalexopoulou, N. (2008). Motor clumsiness in children aged 9-12 years in Greece—An epidemiological study. *Inquiries in Sport and Physical Education*, *6*(3), 280-289. https://doi.org/10.26253/heal.uth.ojs.ispe.2008.1282

Farhat, F., Hsairi, I., Baiti, H., Cairney, J., Mchirgui, R., Masmoudi, K., …, & Moalla, W. (2015). Assessment of physical fitness and exercise tolerance in children with developmental coordination disorder. *Research in Developmental Disabilities*, *45*, 210-219. https://doi.org/10.1016/j.ridd.2015.07.023

Farhat, F., Masmoudi, K., Cairney, J., Hsairi, I., Triki, C., & Moalla, W. (2014). Assessment of cardiorespiratory and neuromotor fitness in children with developmental coordination disorder. *Research in Developmental Disabilities*, *35*(12), 3554-3561. https://doi.org/10.1016/j.ridd.2014.08.028

Faught, B.E., Cairney, J., Hay, J., Veldhuizen, S., Missiuna, C., & Spironello, C.A. (2008). Screening for motor coordination challenges in children using teacher ratings of physical ability and activity. *Human Movement Science*, *27*(2), 177-189. https://doi.org/10.1016/j.humov.2008.02.001

Faught, B.E., Rivilis, I., Klentrou, P., Cairney, J., Hay, J., & Liu, J. (2013). Submaximal oxygen cost during incremental exercise in children with developmental coordination disorder. *Research in Developmental Disabilities*, *34*(12), 4439-4446. https://doi.org/10.1016/j.ridd.2013.09.024

Field, S., Crane, J., Naylor, P.J., & Temple, V. (2020). A longitudinal examination of the accuracy of perceived physical competence in middle childhood. *Journal of Motor Learning and Development, 8*(3), 457-474. https://doi.org/10.1123/jmld.2019-0045

Ghorbani, S., Afshari, M., Eckelt, M., Dana, A., & Bund, A. (2021). Associations between physical activity and mental health in Iranian adolescents during the COVID-19 pandemic: An accelerometer-based study. *Children*, *8*(11), 1022. https://doi.org/10.3390/children8111022

Hebinck, M., Pelletier, R., Labbé, M., Best, K.L., & Robert, M.T. (2023). Exploring knowledge of the concept of physical literacy among rehabilitation professionals, students and coaches practicing in a pediatric setting. *Disabilities*, *3*(4), 493-506 https://doi.org/10.3390/disabilities3040031

Henderson, S.E., Sugden, D.A., & Barnett, A.L. (2007). *Movement assessment battery for children-2 second edition (Movement ABC-2).* London, UK: The Psychological Corporation. https://doi.org/10.1037/t55281-000

International Physical Literacy Association. (2017). *Definition of physical literacy.* Retrieved from www.physical-literacy.org.uk

Jaakkola, T., Huhtiniemi, M., Salin, K., Seppälä, S., Lahti, J., Hakonen, H., & Stodden, D.F. (2019). Motor competence, perceived physical competence, physical fitness, and physical activity within Finnish children. *Scandinavian Journal of Medicine and Science in Sports*, *29*(7), 1013-1021. https://doi.org/10.1111/sms.13412

Kaioglou, V., Adamakis, M., Kossyva, I., Kouloutbani, K., Afthentopoulou, A.E., Mazzoli, E., ..., & Venetsanou, F. (2025). Physical Literacy in Children Questionnaire: Adaptation, validity, and reliability evidence for 4–12-year-old Greek children. *Measurement in Physical Education and Exercise Science*, 1-13. https://doi.org/10.1080/1091367X.2025.2558521

Kaioglou, V., Dania, A., Kambas, A., & Venetsanou, F. (2023). Associations of motor competence, cardiorespiratory fitness, and physical activity: The mediating role of cardiorespiratory fitness. *Research Quarterly for Exercise and Sport, 94*(2), 361-367. https://doi.org/10.1080/02701367.2021.1991559

Kaioglou, V., Dania, A., & Venetsanou, F. (2020). How physically literate are children today? A baseline assessment of Greek children 8-12 years of age. *Journal of Sports Sciences*, *38*(7), 741-750. https://doi.org/10.1080/02640414.2020.1730024

Katartzi, E.S., & Vlachopoulos, S.P. (2011). Motivating children with developmental coordination disorder in school physical education: The self-determination theory approach. *Research in Developmental Disabilities*, *32*(6), 2674-2682. https://doi.org/10.1016/j.ridd.2011.06.005

Kjellenberg, K., Ekblom, Ö., Stålman, C., Helgadóttir, B., & Nyberg, G. (2021). Associations between physical activity patterns, screen time and cardiovascular fitness levels in Swedish adolescents. *Children*, *8*(11), 998. https://doi.org/10.3390/children8110998

Klavina, A., Ostrovska, K., & Campa, M. (2017). Fundamental movement skill and physical fitness measures in children with disabilities. *European Journal of Adapted Physical Activity*, *10*(1), 28-37. https://doi.org/10.5507/euj.2017.004

Kourtessis, T., Tsigilis, N., Maheridou, M., Ellinoudis, T., Kiparissis, M., & Kioumourtzoglou, E. (2008). The influence of a short intervention program on early childhood and physical education teachers' ability to identify children with developmental coordination disorders. *Journal of Early Childhood Teacher Education*, *29*(4), 276-286. https://doi.org/10.1080/10901020802470002

Kourtessis, T., Tzetzis, G., Kioumourtzoglou, E., & Mavromatis, G. (2001). The effects of an intensive recreational intervention program on children with movement difficulties. *New Zealand Journal of Disability Studies, 9,* 120-139.

Kowalski, K.C., Crocker, P.R., & Donen, R.M. (2004). *The physical activity questionnaire for older children (PAQ-C) and adolescents (PAQ-A) manual.* College of Kinesiology, University of Saskatchewan.

Kowalski, K.C., Crocker, P.R., & Faulkner, R.A. (1997). Validation of the physical activity questionnaire for older children. *Pediatric Exercise Science, 9*(2), 174-186. https://doi.org/10.1123/pes.9.2.174

Li, M.H., Sum, R.K.W., Sit, C.H.P., Liu, Y., & Li, R. (2021). Perceived and actual physical literacy and physical activity: A test of reverse pathway among Hong Kong children. *Journal of Exercise Science and Fitness, 19*(3), 171-177. https://doi.org/10.1016/j.jesf.2021.03.001

Li, M.H., Sum, R.K.W., Tremblay, M., Sit, C.H.P., Ha, A.S.C., & Wong, S.H.S. (2020). Cross-validation of the Canadian assessment of physical literacy second edition (CAPL-2): The case of a Chinese population. *Journal of Sports Sciences*, *38*(24), 2850-2857. https://doi.org/10.1080/02640414.2020.1803016

Li, Y.C., Kwan, M.Y., King-Dowling, S., Rodriguez, M.C., & Cairney, J. (2021). Does physical activity and BMI mediate the association between DCD and internalizing problems in early childhood? A partial test of the environmental stress hypothesis. *Human Movement Science*, *75*, 102744. https://doi.org/10.1016/j.humov.2020.102744

Lima, R.A., Bugge, A., Ersbøll, A.K., Stodden, D.F., & Andersen, L.B. (2019). The longitudinal relationship between motor competence and measures of fatness and fitness from childhood into adolescence. *Jornal de Pediatria*, *95*(4), 482-488. https://doi.org/10.1016/j.jped.2018.02.010

Lloyd, M., Saunders, T.J., Bremer, E., & Tremblay, M.S. (2014). Long-term importance of fundamental motor skills: A 20-year follow-up study. *Adapted Physical Activity Quarterly*, *31*(1), 67-78. https://doi.org/10.1123/apaq.2013-0048

Lopes, V.P., Rodrigues, L.P., Maia, J.A., & Malina, R.M. (2011). Motor coordination as predictor of physical activity in childhood. *Scandinavian Journal of Medicine and Science in Sports*, *21*(5), 663- 669. https://doi.org/10.1111/j.1600-0838.2009.01027.x

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. https://doi.org/10.1016/j.humov.2003.09.011

Mengyu, L., Yuxing, W., Ziqing, Z., Lizhu, L., & Lili, Y. (2025). Physical literacy among Chinese elementary school students: The mediating role of physical knowledge and physical competency. *BMC Public Health, 25*(1), 351. https://doi.org/10.1186/s12889-025-21523-y

Meredith, M.D., & Welk, G. (Eds.). (2010). *Fitnessgram and activitygram test administration manual—Updated 4th edition*. Human Kinetics.

Miyahara, M. (2020). Physical literacy as a framework of assessment and intervention for children and youth with developmental coordination disorder: A narrative critical review of conventional practice and proposal for future directions. *International Journal of Environmental Research and Public Health*, *17*(12), 4313. https://doi.org/10.3390/ijerph17124313

Noordstar, J.J., & Volman, M.J.M. (2020). Self-perceptions in children with probable developmental coordination disorder with and without overweight. *Research in Developmental Disabilities*, *99*, 103601. https://doi.org/10.1016/j.ridd.2020.103601

Poitras, V.J., Gray, C.E., Borghese, M.M., Carson, V., Chaput, J.-P., Janssen, I., …, & Tremblay, M.S. (2016). Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Applied Physiology. Nutrition and Metabolism*, *41*(6; Suppl. 3), S197-S239. https://doi.org/10.1139/apnm-2015-0663

Poulsen, A.A., Ziviani, J.M., & Cuskelly, M. (2008). Leisure time physical activity energy expenditure in boys with developmental coordination disorder: The role of peer relations self-concept perceptions. *Occupational Therapy Journal of Research*, *28*(1), 30-39. https://doi.org/10.3928/15394492-20080101-05

Purcell, C., Schott, N., Rapos, V., Zwicker, J.G., & Wilmut, K. (2023). Understanding factors that influence physical activity behavior in people with developmental coordination disorder (DCD): A mixed-methods convergent integrated systematic review. *Frontiers in Human Neuroscience*, *17*, 1274510. https://doi.org/10.3389/fnhum.2023.1274510

Robinson, L.E., Stodden, D.F., Barnett, L.M., Lopes, V.P., Logan, S.W., Rodrigues, L.P., & D'Hondt, E. (2015). Motor competence and its effect on positive developmental trajectories of health. *Sports Medicine*, *45*, 1273-1284. https://doi.org/10.1007/s40279-015-0351-6

Sankar, U.G., & Monisha, R. (2019). Life impact of developmental coordination disorder: Qualitative analysis of patient and therapist experiences. *Biomedical and Pharmacology Journal*, *12*(1), 491. http://dx.doi.org/10.13005/bpj/1666

Schoemaker, M.M., Flapper, B., Verheij, N.P., Wilson, B.N., Reinders-Messelink, H.A., & de Kloet, A. (2006). Evaluation of the developmental coordination disorder questionnaire as a screening instrument. *Developmental Medicine and Child Neurology*, *48*(8), 668-673. https://doi.org/10.1017/S001216220600140X

Schoemaker, M.M., Niemeijer, A.S., Flapper, B.C., & Smits-Engelsman, B.C. (2012). Validity and reliability of the movement assessment battery for children-2 checklist for children with and without motor impairments. *Developmental Medicine and Child Neurology*, *54*(4), 368-375. https://doi.org/10.1111/j.1469-8749.2012.04226.x

Shahzad, N., & Jameel, H.T. (2022). Physical activity and literacy interventions for children with developmental coordination disorder: Present and future preferences. *Journal of Educational Sciences*, *9*(1), 1-16. https://doi.org/10.52587/jesar.09.01.01

Shearer, C., Goss, H.R., Edwards, L.C., Keegan, R.J., Knowles, Z.R., Boddy, L.M., Durden-Myers, E.J., & Foweather, L. (2018). How is physical literacy defined? A contemporary update. *Journal of Teaching in Physical Education*, *37*(3), 237-245. https://doi.org/10.1123/jtpe.2018-0136

St. John, L., Dudley, D., & Cairney, J. (2021). A longitudinal examination of enjoyment of physical education in children with developmental coordination disorder through a physical literacy lens. *Prospects*, *50*(1), 127-139. https://doi.org/10.1007/s11125-020-09469-y

Stodden, D.F., Goodway, J.D., Langendorfer, S.J., Roberton, M.A., Rudisill, M.E., Garcia, C., & Garcia, L.E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*, 60(2), 290-306. https://doi.org/10.1080/00336297.2008.10483582

Sujatha, B., Alagesan, J., Seemathan, P., & Sadhasivam, S. (2020). Cardiorespiratory fitness in children with developmental coordination disorder. *Biomedicine*, *40*(4), 539-542. https://doi.org/10.51248/.v40i4.337

Tremblay, M.S., Costas-Bradstreet, C., Barnes, J.D., Bartlett, B., Dampier, D., Lalonde, C., …, & Yessis, J. (2018a). Canada's physical literacy consensus statement: Process and outcome. *BMC Public Health*, *18*(Suppl 2), 1034. https://doi.org/10.1186/s12889-018-5903-x

Tremblay, M.S., Longmuir, P.E., Barnes, J.D., Belanger, K., Anderson, K.D., Bruner, B., ..., & Woodruff, S.J. (2018b). Physical literacy levels of Canadian children aged 8–12 years: Descriptive and normative results from the RBC Learn to Play–CAPL project. *BMC Public Health, 18*(Suppl. 2), 1036. https://doi.org/10.1186/s12889-018-5891-x

Tsiotra, G.D., Flouris, A.D., Koutedakis, Y., Faught, B.E., Nevill, A.M., Lane, A.M., & Skenteris, N. (2006). A comparison of developmental coordination disorder prevalence rates in Canadian and Greek children. *Journal of Adolescent Health*, *39*(1), 125-127. https://doi.org/10.1016/j.jadohealth.2005.07.011

Utesch, T., Bardid, F., Büsch, D., & Strauss, B. (2019). The relationship between motor competence and physical fitness from early childhood to early adulthood: A meta-analysis. *Sports Medicine*, *49*, 541-551. https://doi.org/10.1007/s40279-019-01068-y

Van der Hoek, F.D., Stuive, I., Reinders-Messelink, H.A., Holty, L., de Blécourt, A.C., Maathuis, C.G., & van Weert, E. (2012). Health-related physical fitness in Dutch children with developmental coordination disorder. *Journal of Developmental and Behavioral Pediatrics*, *33*(8), 649-655. https://doi.org/10.1097/DBP.0b013e3182653c50

Venetsanou, F., Emmanouilidou, K., Soutos, K., Sotiriou, S.A., Bastida, L., Moya, A., Kambas, A. (2020). Towards a functional approach to the assessment of daily life physical activity in children: Are the PAQ-C and Fitbit Flex-2 technically adequate? *International Journal of Environmental Research and Public Health*, *17*(22), 8503. https://doi.org/10.3390/ijerph17228503

Venetsanou, F., & Kambas, A. (2017). Can motor proficiency in preschool age affect physical activity in adolescence? *Pediatric Exercise Science*, *29*(2), 254-259. https://doi.org/10.1123/pes.2016-0119

Venetsanou, F., Kambas, A., Gourgoulis, V., & Yannakoulia, M. (2019). Physical activity in pre-school children: Trends over time and associations with body mass index and screen time. *Annals of Human Biology, 46*(5), 393-399. https://doi.org/10.1080/03014460.2019.1659414

Whitehead, M. (2019). Definition of physical literacy: Developments and issues. In M. Whitehead (Ed.), *Physical literacy across the world* (pp. 8-18). Routledge.

Whitehead, M., & Almond, L. (2013). Creating learning experiences to foster physical literacy. *ICSSPE Bulletin: International Council of Sport Science and Physical Education, 65*, 73-80.

Whitehead, M.E., Durden-Myers, E.J., & Pot, N. (2018). The value of fostering physical literacy. *Journal of Teaching in Physical Education, 37*(3), 252-261. https://doi.org/10.1123/jtpe.2018-0139

Wright, K.E., Furzer, B.J., Licari, M.K., Thornton, A.L., Dimmock, J.A., Naylor, L.H., …, & Jackson, B. (2019). Physiological characteristics, self-perceptions, and parental support of physical activity in children with, or at risk of, developmental coordination disorder. *Research in Developmental Disabilities*, *84*, 66-74. https://doi.org/10.1016/j.ridd.2018.05.013

Yu, J., Sit, C.H., Capio, C.M., Burnett, A., Ha, A.S., & Huang, W.Y. (2016). Fundamental movement skills proficiency in children with developmental coordination disorder: Does physical self-concept matter? *Disability and Rehabilitation*, *38*(1), 45-51. https://doi.org/10.3109/09638288.2015.1014067

Submitted: March 10, 2025
Accepted: October 10, 2025
Published Online First: December 5, 2025

Correspondence to:
Prof. Fotini Venetsanou, Ph.D.
School of Physical Education and Sport Science,
National and Kapodistrian University of Athens,
Greece
41 Ethnikis Antistasis Str., 17237 Athens, Greece
Tel.: +302107276181
Email: fvenetsanou@phed.uoa.gr