Alberta Journal of Educational Research

Prevalence of Motor Difficulties in Greek Preschoolers: The Effect of Gender, Age, BMI, Place of Residence, and Hand Preference

Olga Kechagia, Ermioni S. Katartzi, Eleni Fotiadou et Paraskevi Giagazoglou

Volume 70, numéro 2, été 2024

URI : https://id.erudit.org/iderudit/1112971ar
DOI : https://doi.org/10.55016/ojs/ajer.v70i2.78379

Aller au sommaire du numéro

Éditeur(s)

Faculty of Education, University of Alberta

ISSN

0002-4805 (imprimé)
1923-1857 (numérique)

Citer cet article

Kechagia, O., Katartzi, E., Fotiadou, E. & Giagazoglou, P. (2024). Prevalence of Motor Difficulties in Greek Preschoolers: The Effect of Gender, Age, BMI, Place of Residence, and Hand Preference. *Alberta Journal of Educational Research*, *70*(2), 328–352. https://doi.org/10.55016/ojs/ajer.v70i2.78379

Résumé de l'article

L'objectif principal de la présente étude était d'identifier les difficultés motrices chez les enfants grecs d'âge préscolaire. Les objectifs secondaires étaient d'identifier les différences possibles dans la prévalence des difficultés motrices liées au sexe, à l'âge, à l'indice de masse corporelle, au lieu de résidence et à la préférence manuelle. 302 enfants d'âge préscolaire ont été évalués à l'aide de la première tranche d'âge (3-6 ans) de la batterie d'évaluation du mouvement pour les enfants (2e édition). Les résultats ont montré une forte prévalence de difficultés motrices importantes (12,3 %) et modérées (12,3 %) chez les enfants d'âge préscolaire. Deuxièmement, les effets du sexe, de l'âge, de l'IMC, du lieu de résidence et de la préférence manuelle n'ont pas montré de différences statistiquement significatives (p > 0,05) et nécessitent un examen plus approfondi chez les enfants d'âge préscolaire. Toutefois, des éléments indiquent qu'il peut exister des différences entre les garçons et les filles, les enfants de 4 et 5 ans, les enfants ayant un indice de masse corporelle élevé et ceux ayant un indice de masse corporelle normal, les enfants vivant dans des zones rurales ou urbaines, et les enfants droitiers et gauchers, en ce qui concerne l'apparition de difficultés motrices. Ces résultats soulignent la nécessité d'une évaluation précoce dans les domaines du développement moteur, tels que la dextérité manuelle, les habiletés avec le ballon et l'équilibre, afin d'appliquer des programmes d'éducation physique préscolaire adaptés au développement, dans le but d'aider les enfants d'âge préscolaire à surmonter leurs difficultés et à être physiquement actifs plus tard dans la vie.

Alberta Journal of Educational Research, Vol. 70.2, Summer 2024, 328-352

Prevalence of Motor Difficulties in Greek Preschoolers: The Effect of Gender, Age, BMI, Place of Residence, and Hand Preference

Olga Kechagia, Ermioni S. Katartzi, Eleni Fotiadou, Paraskevi Giagazoglou

Aristotle University of Thessaloniki

The main aim of the present study was to identify motor difficulties in Greek preschoolers. Secondary aims were to identify possible differences in prevalence of motor difficulties related to gender, age, body mass index, place of residence, and hand preference. 302 preschoolers were assessed using the first age band (3–6 years) of the Movement Assessment Battery for Children (2nd edition). The results showed high prevalence of significant (12.3%) and moderate (12.3%) motor difficulties in preschool children. Moreover, gender, age, BMI, place of residence, and hand preference effects showed no statistically significant differences (p > 0.05) and need further consideration among preschool children. However, there was evidence that some differences may exist between boys and girls, 4- and 5-year-old children, children with high and typical body mass index, children living in rural or urban areas, and right- and left-handed children, regarding the occurrence of motor difficulties. These findings highlighted the need for early assessment in domains of motor development, such as hand dexterity, ball skills and balance in order developmentally appropriate preschool physical education programs to be applied, with the aim to help preschoolers improve their difficulties and be physically active later in life.

L'objectif principal de la présente étude était d'identifier les difficultés motrices chez les enfants grecs d'âge préscolaire. Les objectifs secondaires étaient d'identifier les différences possibles dans la prévalence des difficultés motrices liées au sexe, à l'âge, à l'indice de masse corporelle, au lieu de résidence et à la préférence manuelle. 302 enfants d'âge préscolaire ont été évalués à l'aide de la première tranche d'âge (3–6 ans) de la batterie d'évaluation du mouvement pour les enfants (2e édition). Les résultats ont montré une forte prévalence de difficultés motrices importantes (12,3 %) et modérées (12,3 %) chez les enfants d'âge préscolaire. Deuxièmement, les effets du sexe, de l'âge, de l'IMC, du lieu de résidence et de la préférence manuelle n'ont pas montré de différences statistiquement significatives (p > 0,05) et nécessitent un examen plus approfondi chez les enfants d'âge préscolaire. Toutefois, des éléments indiquent qu'il peut exister des différences entre les garçons et les filles, les enfants de 4 et 5 ans, les enfants ayant un indice de masse corporelle élevé et ceux ayant un indice de masse corporelle normal, les enfants vivant dans des zones rurales ou urbaines, et les enfants droitiers et gauchers, en ce qui concerne l'apparition de difficultés motrices. Ces résultats soulignent la nécessité d'une évaluation précoce dans les domaines du développement moteur, tels que la dextérité manuelle, les habiletés avec le ballon et l'équilibre, afin d'appliquer des programmes d'éducation physique préscolaire adaptés au développement, *dans le but d'aider les enfants d'âge préscolaire à surmonter leurs difficultés et à être physiquement actifs plus tard dans la vie.*

Developmental coordination disorder (DCD) is a chronic neurodevelopmental disorder causing motor difficulties that interfere with activities of daily living, academic performance, leisure, and play, without the existence of other neurological or pathological conditions. Moreover, the acquisition and performance of coordinated motor skills are below expected levels for chronological age and learning abilities, leading to a range of negative secondary motor, cognitive, social, and psychological problems (American Psychiatric Association [APA], 2013). Although its onset is in early developmental age and its estimated prevalence is 5–6% (APA, 2013), an official diagnosis is not recommended by the European Academy of Childhood Disability (EACD) prior to the age of five (Blank et al., 2012), when motor development is characterized by intra-individual variability (Darrah et al., 2009). However, it is recommended that motor difficulties should be identified as early as possible to prevent secondary consequences and improve children's function (Piek et al., 2012), before they enter the first stage of formal education in Greece at age 6 (Venter et al., 2015).

Early identification of motor coordination difficulties associated with DCD have been widely addressed, with contradicting results regarding the prevalence and possible factors that might affect them. In many cases, the prevalence is similar to that reported for older children (APA, 2013), with rates of severe motor difficulties at 5–6% (Giagazoglou et al., 2011; Gwynne & Blick, 2004; Jin et al., 2015; Mercê et al., 2019; Valentini et al., 2012; Zaragas & Gajoya, 2019) or even lower (Kokštejn et al., 2017a; Kourtessis et al., 2008; Van Waelvelde et al., 2008). Other studies report higher prevalence, with percentages ranging from 9.9% to 27% (Amador-Ruiz et al, 2018; Freitas et al., 2014; Jelovčan & Zurc, 2016; Nordbye-Nielsen & Kesmodel 2014; Serbetar et al., 2019; Valentini et al., 2012; Venter et al., 2015). Moreover, factors such as gender (Venetsanou & Kambas, 2016), age (Venetsanou & Kambas, 2011), handedness (Giagazoglou et al., 2001), somatometric characteristics (Zaragas et al., 2013), as well as the environment where the child grows up (Giagazoglou et al., 2007) can influence the rate of motor skill development and may account for this wide variation among DCD population. It is therefore evident that motor difficulties are already present at preschool age, despite differences in prevalence and factors that might influence their occurrence.

Gender differences in motor skill development have been reported several times and appear to be evident as early as preschool age (Malina, 2004). However, these findings are not all-inclusive because some studies report similar motor skill development levels among boys and girls (Chambers & Sugden, 2002; Singh et al., 2015; Venetsanou & Kambas 2011). These gender differences could be attributed to a complex interaction between environmental, sociocultural, and biological factors (Giagazoglou et al., 2011; Kourtessis et al., 2008; Livesey et al., 2007; Malina, 2004). DCD is thought to be more prevalent in boys than girls, with the ratio between boys and girls ranging from 2:1 to 7:1 (APA, 2013). Therefore, when assessing gender differences in preschoolers, factors such as opportunities to learn motor skills, frequency of practice of these skills, and appropriateness of assessment instruments should be considered (Malina, 2004).

Regarding age, it is generally accepted that motor development undergoes continuous changes, and that motor coordination improves during childhood due to better integration of sensory and motor systems (Gallahue et al., 2006). Available developmental data show that general motor skill development improves with age (Chow et al., 2006; Largo et al., 2003) and fine and gross motor skills (Gidley-Larson et al, 2007). However, there is also a group of researchers who argued that in children with motor difficulties, the development of motor skills is not always linear, but often a decreasing trajectory is observed (Wright & Sugden, 1998), even during the preschool years (Freitas et al., 2014; Venter et al., 2015). This argument is based on the notion that inadequate participation in physical activities in children with motor impairments becomes more pronounced as play becomes more complex and motor demands increase (Wall, 2004), leading to withdrawal from physical activities and ultimately worsening motor impairments (Stodden et al., 2008; Wall, 2004).

Indeed, children with DCD are often reported to have lower levels of participation in organized play or physical activity (Cairney et al., 2005b), leading to poor physical fitness (Cairney & Veldhuizen, 2013) and often childhood obesity (Cairney et al., 2005a; Schott et al., 2007; Zhu et al., 2011). It was suggested that children with DCD are engaged into a negative cycle, as they avoid participation in physical activities due to their low motor competence; this causes them to adopt a sedentary lifestyle which further decreases their motor competence and deteriorates their physical fitness levels as well as their overall health (Green et al., 2011; Katartzi & Vlachopoulos, 2011; Monastiridi et al., 2020). Precise causal relationships between DCD and obesity are not yet known. Some studies report DCD as a risk factor for obesity (Cairney et al., 2011; Schott et al., 2007), while others emphasize the effects of obesity on motor coordination (D'Hondt et al., 2009) and, conversely, that weight loss can improve gross motor coordination (D'Hondt et al., 2011). This negative relationship between body mass index (BMI) and motor performance begins in preschool (Bonvin et al., 2012; Castetbon & Andreyeva, 2012; Logan et al., 2011) but appears to strengthen throughout childhood (D'Hondt et al., 2011; Lopes et al., 2012); it can vary across abilities (Castetbon & Andreyeva, 2012; Roberts et al., 2012), with predominantly gross motor skills being affected (Graf et al., 2004; Okely et al., 2004). Thus, the reciprocal relationship that appears to exist between obesity and physical inactivity may exacerbate coordination difficulties by reducing participation in physical activity in early childhood (Lopes et al., 2012; Williams et al., 2008).

Participation in physical activity, and thus the development of motor skills in early childhood, is influenced by environmental characteristics in addition to obesity (Puciato et al., 2011; Suliga, 2009; Venetsanou & Kambas, 2010). Among these, place of residence—rural or urban—geographic location, and population density appear to determine children's relationship with physical activity (Hulteen et al., 2018; Niemistö et al., 2019). Several studies have examined the relationship between place of residence, physical activity, and motor development (Dana et al., 2011; Karkera et al., 2014; Kriemler et al., 2008; Loucaides et al., 2007; Tsimeas et al., 2005; Wang et al., 2013) with ambiguous results. The general hypothesis supporting this relationship is that more space for exercise, easier access to it, and time spent in outdoor activities—elements that characterize rural areas in particular—are positively associated with physical activity and contribute to motor skills development. Not surprisingly, places of residence with the above-mentioned characteristics have higher levels of physical activity participation and lower rates of childhood obesity (Jones et al., 2009; Kriemler et al., 2008; Mamalakis et al., 2000; Oezdirenç et al., 2005; Simen-Kapeu et al., 2010). Differences were also found in the type of motor skills developed, depending on the living environment. Better performance in gross motor skills was observed in children from rural areas (Cappellini et al., 2008; Giagazoglou et al., 2007; Sasso et al., 2018), while children from urban areas showed better performance in fine motor skills (Giagazoglou et al., 2007), confirming the above hypothesis. The correlation that seems to exist between place of residence and obesity as well as physical and motor skill development could therefore lead to the conclusion that children living in different areas should be expected to have different motor skills.

Another factor that might affect motor skill development and has been associated with DCD is inconsistent handedness and left-handedness (Cairney et al., 2008; Darvik et al., 2018; Flouris et al., 2005; Freitas et al., 2014; Markou et al., 2017; Rodger et al., 2003). However, few studies have explicitly examined this relationship. The general assumption is that the prevalence of left-handedness is higher in individuals with DCD than in the general population and is similar to the prevalence reported in children with other developmental disabilities (Darvik et al., 2018). This hypothesis seems to be supported by studies in school-aged children (Cairney et al., 2008; Freitas et al., 2014) and preschool-aged children (Giagazoglou et al., 2001; Mori et al., 2007), which confirm a higher prevalence of the disorder in left-handed children and children with unstable and mixed handedness. On the other hand, there are also studies that show no association between handedness and motor or developmental difficulties (Armitage & Larkin, 1993; Bala et al., 2010; Landgren et al., 2000) or report ambiguous results (Dussart, 1994). Although there is no comprehensive research on the effect of handedness on motor difficulties and most research focused on school-aged children, it is useful to investigate and identify potential differences and difficulties that may arise from hand preference so that they can be appropriately addressed in early childhood (Giagazoglou et al., 2001).

It appears that motor difficulties become apparent in early childhood and depend on environmental and biosocial factors that may influence the typical course of motor development. Considering the secondary consequences (Alesi et al., 2019; Kennedy-Behr et al., 2013; Mikami et al., 2020; Piek et al., 2008; Rodriguez et al., 2019; Rosenblum et al., 2017) and the long-term effects of low motor skill development (Cantell & Crawford, 2008; Cairney & King-Dowling, 2016; Causgrove Dunn & Dunn, 2006; Dewey et al., 2002; Larkin & Rakimov, 2006), early and accurate identification and recognition of motor difficulties seems to be of utmost importance in order to provide the child with the necessary support (Piek et al., 2012) by developing and implementing appropriate educational intervention strategies (Missiuna et al., 2011; Pulzi & Rodrigues, 2015). Thus, it was first hypothesized that the occurrence of motor difficulties in preschoolers would be in line with international literature. Second, it was hypothesized that preschoolers would be differentiated in the occurrence of motor difficulties according to their gender (boys and girls). Third, it was hypothesized that preschoolers would be differentiated in the occurrence of motor difficulties according to age (4 and 5 years old). The fourth hypothesis was that preschool children with higher BMI would be differentiated in the occurrence of motor difficulties by children with lower BMI. The fifth hypothesis was that place of residence (rural or urban) would affect the occurrence of motor coordination difficulties among preschoolers. The final hypothesis was that right- and left-handed preschoolers would be differentiated in the occurrence of motor difficulties. Therefore, the main aim of the present study was to identify motor difficulties in Greek preschoolers. Secondary aims were to identify possible differences in prevalence of motor difficulties related to gender, age, BMI, place of residence, and hand preference.

Methods

Participants

Three hundred and two children (n = 302) aged 3 to 6 years (average age = 59.37 months) were recruited from thirteen of the seventeen public preschools located in the district of Florina, Northwest Greece. Boys represented 51.9% of the total sample (*n* = 157 children) and girls 48.01% of the total sample (*n* = 145 children). The sample was divided into three age groups, three-year-olds (36–47 months, *n* = 5), four-year-olds (48–59 months, *n* = 144) and five-year-olds (60–71 months, *n* = 153). All parents or legal guardians of the preschool children were informed about testing procedures, and corresponding written consent was obtained prior to participation. Children with a known history of an intellectual, physical, or emotional disability, as well as special educational needs, were excluded from the assessment, following the guidelines regarding the occurrence of comorbidity in DCD (APA, 2013). The present study was approved by the Institute of Educational Policy of Ministry of Education, Research and Religious Affairs of Greece, and permission was obtained for children's involvement and access to relevant information.

Assessment Instrument

Age band one (3–6 years) of Movement Assessment Battery for Children (2nd Edition; Henderson et al., 2007) was used for the children's assessment. This specific motor test is designed to assess motor skills and identify children with DCD, while providing information and quality observations on areas where potential deficits occur, the level of motor development and the effectiveness of motor intervention programs (Henderson et al., 2007). First age band of MABC-2 consists of eight test items divided into three categories: manual dexterity (posting coins, threading beads, drawing trail), ball skills (aiming, catching) and static and dynamic balance (one leg balance, walking on heels, jumping on mats). A trial effort is performed prior to each test item. For those test items allowing two official attempts, the best of the two is evaluated. An attempt is classified as Failed (F) if the child cannot complete it properly, as a Refusal (R) if the child refuses to perform it, and as Inappropriate (I) if the child has inappropriate behavior during execution.

Raw scores derived from each test item are converted into age-adjusted item Standard Scores (SS) and Component Standard Scores (CSS). The total standard score can be transformed into an age-adjusted percentile rank according to the test manual norms. For all ages, the MABC-2 manual suggests that children who score ≤ 5th percentile (Red Zone) have a significant movement difficulty, while those who score within the 6th–15th percentile (Amber Zone) are "at risk" of having a movement difficulty and require monitoring. Children who score ≥ 16th percentile (Green Zone) do not have a motor impairment (Henderson et al., 2007). Clinically, a cut-off score of ≤ 15th percentile to diagnose children with DCD is recommended, while a stricter cut-off score of ≤ 5th percentile is recommended for children ages 3–5 years (Blank et al., 2012).

Study Design and Procedure

A screening procedure was performed to identify children with motor difficulties. The MABC-2 test was used to evaluate Criterion A of the *Diagnostic and Statistical Manual of Mental Disorders* (5th edition; *DSM-5*), which stands for the identification of motor impairments. At this stage, children were assessed individually in an available area inside the school settings and during the school program. All children were tested by the same researcher, with each child requiring about 20 minutes to complete the assessment. The evaluation phase lasted three months and took place from January to March. At the end of the assessment process, the children were classified into three categories according to the "traffic light system" proposed by the MABC-2 manual: Green Zone = no motor difficulties, Amber Zone = moderate motor difficulties, and Red Zone = significant motor difficulties.

Statistical Analysis

Categorical variables were presented as absolute frequencies (*n*) and relative frequencies (%), while the quantitative variables were presented either as means and standard deviations (if followed the normal distribution) or as medians and amplitudes (if not followed the normal distribution). The Kolmogorov-Smirnov and Shapiro-Wilk tests, as well as Q-Q Plots, were used to check the normal distribution of the quantitative variables.

The chi-square Test of Independence was used to investigate the relationship between two categorical variables. Between a quantitative variable (following the normal distribution) and a categorical one (with two categories) the *t*-test for independent samples (Independent samples *t*-test) was used, while in case of an abnormal quantitative variable, the non-parametric Mann-Whitney test was applied. For categorical with three categories the one-way ANOVA was used.

The two-sided level of statistical significance was set equal to 0.05. The statistical processing and analysis of the survey data was performed using the statistical package SPSS, version 22.0.

Results

The anthropometric features by category of motor competence are presented in Table 1. The parametric ANOVA test between zones showed no statistically significant differences in the mean weight of children between the three risk zones [$F_{(2.299)} = 0.88$, $p = 0.417$]. Similarly, the BMI of children with severe motor difficulties did not differ significantly from those without any motor difficulties nor from those at risk [$F_{(2.299)} = 0.84$, $p = 0.432$]

Out of the 302 children, 228 (75.5 %) were above the 15th percentile (Standard Score above 67) indicating no motor problems. Thirty-seven children (12.3 %) were ranked between the 5th and 15th percentile inclusive, thus classified “at risk” of having a movement difficulty (Standard Score between 57 and 67), while 37 children (12.3 %), revealed significant motor difficulties (Standard Score up to and including 56), as seen in Table 2.

Table 2 presents the number of children and their respective percentages, according to age in the three separate categories: (a) no movement difficulties, (b) at risk, and (c) significant movement difficulties.

Table 1

Anthropometric Characteristics by Category

	Zones of motor difficulty					
	No motor difficulties (Green Zone) (*n* = 228)	At risk (Amber Zone) (*n* =37)	Definite motor difficulties (Red Zone) (*n* = 37)	Statistical test *	*p* value	Effect Size
Characteristic	Mean (Standard Deviation)					
Weight (kg)	19.49 (3.65)	20.37 (4.73)	19.36 (4.57)	$F(2.299) = 0.88$	$p = 0.417$	η2 = 0.006
Height (cm)	112.24 (6.29)	112.70 (6.28)	111.60 (6.37)	$F(2.299) = 0.28$	$p = 0.751$	η2 = 0.002
BMI (kg/m^2)	15.40 (2.09)	15.92 (2.71)	15.41 (2.60)	$F(2.299) = 0.84$	$p = 0.432$	η2 = 0.006
Age (months)	59.73 (6.73)	58.68 (6.61)	57.84 (6.63)	$F(2.299) = 1.50$	$p = 0.225$	η2 = 0.010

*Parametric test: ANOVA between zones of motor difficulty.

Table 2

Distribution of Children by Age (Age Percentages)

Zones of movement difficulty	Total (N = 302)	Age		
		3 years [3–3 years & 11 months]	4 years [4–4 years& 11 months]	5 years [5–5 years & 11 months]
	n (%)			
No movement difficulties (Green Zone)	228 (76.2)	3 (60.0)	104 (72.2)	121 (79.1)
At risk (Amber Zone)	37 (12.3)	1 (20.0)	18 (12.5)	18 (11.8)
Significant movement difficulties (Red Zone)	37 (12.3)	1 (20.0)	22 (15.3)	14 (9.2)

Table 3

Comparison of the Scores of Each Domain Between Boys and Girls in Each Zone of Motor Difficulty

	Variables	Gender Mean (Standard Deviation)		*t(df)**	p value	Effect Size
At risk (n = 37)		Male (n = 20)	Female (n = 17)			
	Dexterity	16.55 (5.26)	17.76 (4.53)	$t(35) = -0.74$	$p = 0.462$	$d = 0.25$
	Ball Skills	18.35 (3.64)	16.53 (2.48)	$t(35) = 1.74$	$p = 0.090$	$d = 0.58$
	Balance	25.05 (4.85)	24.59 (5.15)	$t(35) = 0.28$	$p = 0.781$	$d = 0.09$
Significant difficulties (n = 37)		Male (n = 22)	Female (n = 15)			
	Dexterity	13.36 (5.72)	13.33 (4.94)	$t(35) = 0.01$	$p = 0.987$	$d = 0.01$
	Ball Skills	14.55 (3.28)	14.60 (3.76)	$t(35) = -0.47$	$p = 0.963$	$d = 0.01$
	Balance	18.27 (5.80)	18.67 (7.37)	$t(35) = -0.18$	$p = 0.857$	$d = 0.06$

*Independent samples t-test for comparison between genders.

No statistically significant gender differences were observed in the scores of the three domains for both children at risk (Amber Zone) and children with severe motor difficulties (Red Zone). As Table 3 shows, for all comparisons $p > 0.05$.

Regarding children at risk, those at age 4 years achieved significantly higher scores (M.O. = 19.5 vs. M.O. = 14.28) in the domain of hand dexterity [$t_{(34)} = 3.86$, $p < 0.001$]. In contrast, 5-year-old children significantly outperformed in the balance domain (M.O. = 26.67 versus M.O. = 23.23) [$t_{(34)} = 3.86$, $p < 0.001$]. In the ball skills domain, there was no statistically significant difference between the two age groups [$t_{(223)} = -1.33$, $p = 0.185$].

Finally, for children with significant motor difficulties (Red Zone), no statistically significant differences in scores in the three domains were observed between the two age groups (for all comparisons $p > 0.05$), as noted in Table 4.

For children in the Amber Zone, a statistically significant difference between normal weight and overweight/obese children was found only in the ball skills domain, with the former achieving a mean score of 18.28 compared to 14.75 for the overweight/obese [$t_{(35)} = 2.99$, $p = 0.005$]. No

Table 4

Comparison of Scores in Each Domain Between Children Aged 4 and 5 years in Each Zone

	Variables	Age * Mean (Standard Deviation)		*t*(*df*)**	*p* value	Effect Size
At risk (n = 37)		4 years (n = 18)	5 years (n = 18)			
	Dexterity	19.50 (4.47)	14.28 (3.59)	*t*(34) = 3.86	*p* <0.001	*d* = 1.29
	Ball Skills	16.61 (3.53)	18.50 (2.81)	*t*(34) = −1.77	*p* = 0.085	*d* = 0.59
	Balance	23.33 (3.86)	26.67 (5.33)	*t*(34) = −2.14	*p* = 0.039	*d* = 0.72
Significant difficulties (n = 37)		4 years (n = 22)	5 years (n = 14)			
	Dexterity	13.18 (5.90)	13.36 (4.68)	*t*(34) = −0.09	*p* = 0.926	*d* = 0.03
	Ball Skills	13.95 (3.15)	15.64 (3.79)	*t*(34) = 1.45	*p* =0.157	*d* = 0.48
	Balance	18.00 (6.84)	19.21 (6.01)	*t*(34) = −0.54	*p* = 0.591	*d* = 0.19

Note. 4 years = [4–4 years & 11 months], 5 years = [5–5 years & 11 months].
*The 3 years category was excluded due to a small number of observations.
**Independent samples t-test for comparison between age groups.

Table 5

Comparison of the Scores of Each Domain Based on BMI for Each Zone

	Variables	BMI Mean (Standard Deviation)		*t*(*df*)*	*p* value	Effect Size
At risk (n = 37)		Normal Weight (n = 29)	Overweight/ Obese (n = 8)			
	Dexterity	16.76 (4.91)	18.38 (5.01)	*t*(35) = −0.82	*p* = 0.418	*d* = 0.33
	Ball Skills	18.28 (2.97)	14.75 (2.81)	*t*(35) = 2.99	*p* = 0.005	*d* = 1.22
	Balance	24.62 (5.15)	25.63 (4.21)	*t*(35) = −0.50	*p* = 0.616	*d* = 0.21
Significant difficulties (n = 37)		Normal Weight (n = 28)	Overweight/ Obese (n = 9)			
	Dexterity	13.82 (4.80)	11.89 (6.92)	*t*(35) = 0.94	*p* = 0.353	*d* = 0.32
	Ball Skills	14.64 (3.48)	14.33 (3.46)	*t*(35) = 0.23	*p* = 0.817	*d* = 0.09
	Balance	18.82 (6.86)	17.22 (4.74)	*t*(35) = 0.65	*p* = 0.521	*d* = 0.27

*Independent samples t-test for comparison between normal weight children and overweight/obese children.

significant difference was observed in the areas of hand dexterity and balance ($p > 0.05$).

Finally, for children with significant motor difficulties, no statistically significant differences were observed in the scores of the three domains between overweight/obese and normal weight ($p > 0.05$), as shown in Table 5.

Comparisons in the scores of the three domains according to place of residence for each zone, did not show any statistically significant results (all $p > 0.05$) as demonstrated in Table 6.

In none of the risk zones of motor difficulty and for none of the three domain scores,

Table 6

Comparison of the Scores of Each Domain Based on Place of Residence for Each Zone

	Variables	Residence Mean (Standard Deviation)		*t*(*df*)*	*p* value	Effect Size
		Rural (n = 28)	Urban (n = 9)			
At risk (n = 37)	Dexterity	16.61 (5.01)	18.67 (4.52)	*t*(35) = −1.10	*p* = 0.280	*d* = 0.43
	Ball Skills	17.64 (3.50)	17.11 (2.47)	*t*(35) = 0.42	*p* = 0.676	*d* = 0.17
	Balance	25.25 (4.58)	23.56 (4.92)	*t*(35) = 0.89	*p* = 0.377	*d* = 0.32
		Rural (n = 34)	Urban (n = 3)			
Significant difficulties (n = 37)	Dexterity	13.32 (5.56)	13.67 (2.08)	*t*(35) = −0.10	*p* = 0.917	*d*=0.08
	Ball Skills	14.50 (3.30)	15.33 (5.50)	*t*(35) = −0.39	*p* = 0.692	*d*=0.18
	Balance	18.88 (6.26)	13.33 (6.66)	*t*(35) = 1.46	*p* = 0.152	*d*=0.86

*Independent samples t-test for comparison by place of residence.

Table 7

Comparison of the Scores of Each Domain Between Right and Left Hand in Each Zone

	Variables	Handedness Mean (Standard Deviation)		*t*(*df*)*	*p* value	Effect Size
		Right (n = 30)	Left (n = 7)			
At risk (n = 37)	Dexterity	17.23 (4.30)	16.57 (7.43)	*t*(35) = 0.32	*p* = 0.753	*d* = 0.11
	Ball Skills	17.70 (2.74)	16.71 (5.12)	*t*(35) = 0.72	*p* = 0.478	*d* = 0.24
	Balance	24.13 (4.58)	27.86 (5.55)	*t*(35) = −1.86	*p* = 0.071	*d* = 0.73
		Right (n = 30)	Left (n = 7)			
Significant difficulties (n = 37)	Dexterity	12.97 (5.13)	15.00 (6.35)	*t*(35)=-0.90	*p* = 0.373	*d* = 0.35
	Ball Skills	14.53 (3.63)	14.71 (2.63)	*t*(35)=-0.12	*p* = 0.902	*d* = 0.06
	Balance	17.90 (6.26)	20.71 (6.92)	*t*(35)=-1.05	*p* = 0.300	*d* = 0.42

*Independent samples t-test for the comparison based on the dominant hand.

statistically significant differences were observed between left- and right-handed children (for all comparisons, $p > 0.05$), as noted in Table 7.

Cohen's d effect sizes (ES) for each one of the motor skills variables, gender, age, BMI, place of residence, and handedness group comparisons are presented in Table 8. A d value of .20 denotes a small ES, a value of .50 a medium ES, and a value of .80 or greater a large ES (Cohen, 1988).

Among children detected with significant motor difficulties, a large effect size was observed for place of residence in relation to balance; a large effect size was also observed for hand dexterity and ball skills in relation to age and BMI respectively, but only among children categorized at risk for motor difficulties. In addition, among children at risk for motor difficulties, a moderate effect size was found in ball skills in relation to age and gender, and in balance in relation to age and handedness.

Table 8

Effects Sizes for Each Variable in the Three Domains

			Cohen's d		
Motor Variables	Gender	Age	BMI	Residence	Handedness
Children at risk for movement difficulties					
Dexterity	*d* = 0.25	*d* = 1.29	*d* = 0.33	*d* = 0.43	*d* = 0.11
Ball Skills	*d* = 0.58	*d* = 0.59	*d* = 1.22	*d* = 0.17	*d* = 0.24
Balance	*d* = 0.09	*d* = 0.72	*d* = 0.21	*d* = 0.32	*d* = 0.73
Children with significant movement difficulties					
Dexterity	*d* = 0.01	*d* = 0.03	*d* = 0.32	*d* = 0.08	*d* =0.35
Ball Skills	*d* = 0.01	*d* = 0.48	*d* = 0.09	*d* = 0.18	*d* = 0.06
Balance	*d* = 0.06	*d* = 0.19	*d* = 0.27	*d* = 0.86	*d* = 0.42

Discussion

The main aim of the present study was to identify motor difficulties in Greek preschoolers. Secondary aims were to identify possible differences in prevalence of motor difficulties related to gender, age, body mass index, place of residence, and hand preference. According to the first hypothesis regarding the occurrence of motor difficulties in preschoolers, the results of the present study were in line with the scientific literature, revealing a relatively high prevalence in preschoolers. The percentage of preschoolers presented with significant motor difficulties (12.3%), and with an overall motor score below the 5th percentile position (Red Zone) shows that the occurrence of motor difficulties in preschoolers is higher than school-age children and needs further investigation (APA, 2013). Regarding moderate motor difficulties, the results showed an occurrence of 12.3% of motor difficulties below the 15th percentile position (Amber Zone), which indicates that the findings of the present study are in line with literature regarding school-age (Ellinoudis et al., 2008; Tsiotra et al., 2006; Valentini et al., 2012) and preschool-age children (Della Barba et al., 2017, Kokštejn et al., 2017a; Kourtessis et al., 2008; Venter et al., 2015). Overall, these results are in line with the general estimates for DCD, which refer to a range between 2 and 20% of school-age children presenting with significant and moderate motor difficulties (Blank et al., 2019). However, previous research in Greek preschoolers indicated that the prevalence of significant motor difficulties was found to be lower compared to the results of the present study and was similar to the results of previous studies reported for DCD (APA, 2013; Giagkazoglou et al., 2011; Kourtessis et al., 2008; Zaragas & Gatzogia, 2019). In particular, the prevalence of severe motor difficulties has been reported between 1.6% (Kourtessis et al., 2008) and 5.4% (Giagazoglou et al., 2011, Zaragas & Gatzogia, 2019) while higher percentages, consistent with the present study, have been reported only regarding children with moderate motor difficulties (Kourtessis et al., 2008). According to international literature, several studies investigated the prevalence of DCD in preschool children using MABC-2, reporting a prevalence of moderate and significant motor difficulties similar (Kokštejn et al., 2017a; Mercê et al., 2019; Serbetar et al., 2019), or even higher (Jelovčan & Zurc, 2016; Valentini et al., 2012; Venter et al., 2015) than that indicated in the present study. Conclusively, significant or moderate motor difficulties in preschoolers seemed to exist and it is an issue that should be addressed by researchers and educational professionals.

According to the second hypothesis results showed no gender differences regarding the occurrence of motor difficulties, although a higher occurrence in boys both in significant and moderate motor difficulties was shown. Among children with moderate motor difficulties, girls outperformed boys in hand dexterity, whereas boys performed better in gross motor skills (ball skills, balance). However, these differences were also not statistically significant, although a moderate effect size was found regarding ball skills. According to previous research, most of which referred to school-age children, the ratio of boys to girls with motor difficulties due to DCD varied from 2:1 to 7:1 (APA, 2013). In preschool children, gender comparisons of motor difficulties yielded ambiguous results. While some researchers reported a higher prevalence in boys for both significant and moderate motor difficulties (Chow et al., 2001; Jin et al., 2015; Kourtessis, et al., 2008; Livesey et al., 2007; Sigmundsson & Rostoft, 2003; Zaragas & Gatzoya, 2019), others reported differences only in specific motor skills, with girls outperforming boys in hand dexterity (Kokštejn et al., 2017b; Sigmundsson & Rostoft, 2003) and balance (Hirata et al., 2018; Kita et al., 2016; Olesen et al., 2014), while boys performed better in ball skills (Chow et al., 2006; Engel-Yeger et al., 2010; Giagazoglou et al., 2011; Jelovčan & Zurc, 2016; Junaid & Fellowes, 2006; Kokštejn et al., 2017b; Livesey et al., 2007; Olesen et al., 2014). Finally, a smaller proportion of surveys found similar results in the occurrence of motor difficulties comparing boys and girls (Barba et al., 2017; Kambas et al., 2012; Kokštejn et al., 2017b; Saraiva et al., 2013; Valentini et al., 2014; Van Waelvelde et al., 2008), or higher prevalence of motor difficulties in preschool girls (Jelovčan & Zurc, 2016; Valentini et al., 2012; Venter et al., 2015). The results of the present study confirmed the suggestion that the biological characteristics of preschool-aged boys and girls are similar (Nelson et al., 1986; Thomas & French, 1985) and that any differences and discrepancies are due to the child's cultural and social context rather than to differential biological maturation (Malina, 2004; Thomas et al., 2000). Body growth throughout the first years of childhood is the same for both genders (Livesey et al., 2007; Spessato et al., 2012), as boys and girls have similar height, weight, and physical build (Cratty, 1994). In addition, according to Cleland and Gallahue (1993), boys and girls share common experiences from 4 to 8 years of age, and they are not differentiated in their motor development. Therefore, motor competence among genders in early childhood can be described as similar rather than different (Venetsanou & Kambas, 2016). All in all, although there are not distinct differences between genders in motor development in preschoolers, further research regarding the occurrence of motor difficulties is encouraged.

In line with the third hypothesis, preschool children's occurrence of motor difficulties was not statistically different regarding age. However, a higher percentage of children aged 4 years (15.3%) was observed to be presented with significant motor difficulties than children aged 5 years (14%). Also, a large effect size was found for hand dexterity, while a moderate effect size was found for ball skills and balance among children with moderate motor difficulties regarding age. Children aged 3 years were not included in this comparison because of the small sample size (n = 5). These results are consistent with those of the MABC-2 standardization (Henderson & Sugden, 1992) and indicate that older children perform better on average compared to younger children. Similar results have been reported in previous studies in preschoolers (Jin et al., 2015; Van Waelvelde et al., 2008; Williams et al., 2008), suggesting that younger age may be a risk factor for the prevalence of DCD (Saraiva et al., 2013; Venter, et al., 2015). Moreover, previous studies in Greece showed that older children performed better than younger ones in ball skills and hand dexterity (Giagazoglou et al., 2011); in hand dexterity and balance (Livesey et al., 2007); in writing, motor skills, vision, and balance (Vlachos et al., 2014); and in general motor skills (Dourou et al., 2017). Although the findings of the present study were not consistent with the results of other research studies (Engel-Yeger et al., 2010, Zachopoulou & Makri, 2005), they nevertheless seemed to suggest that older children show greater control and gradual improvement in their movements. This positive effect of age on motor adequacy could describe a gradual adaptation of the motor system to its demands (Hadders-Algra, 2000; Thelen, 1995) and aligns with the general assumption that motor maturation occurs with age (Castetbon & Andreyeva, 2012; Chow et al., 2006; Kambas et al., 2012; Livesey et al., 2007; Venetsanou et al., 2011). Age is the variable that reflects the biological and neurological maturation of the child as well as the environment. It is also logical that the interaction of maturation and environmental factors may help explain the increasing variability in motor development with age (Saraiva et al., 2013). However, the controversy comes from a group of researchers who claim that as children grow, their motor difficulties increase (Beitel & Mead, 1982; Freitas et al., 2014; Wright & Sugden, 1998), a statement that could not be evaluated in such a small age range as that of the present study and needs further investigation.

Regarding the fourth hypothesis, preschoolers were not differentiated in the occurrence of motor difficulties in relation to BMI. However, there were indications that preschoolers with moderate motor difficulties and higher BMI performed worse in ball skills, and that preschoolers with significant motor difficulties and higher BMI also performed worse in all subcategories (hand dexterity, ball skills, balance), compared with typically weighted peers. The results of the present study are consistent with findings of previous studies, which found that BMI does not affect motor performance and the occurrence of motor difficulties in preschoolers (Papadopoulos et al., 2008; Zaragas et al., 2013), and that there is no statistically significant correlation between BMI and motor coordination difficulties in the early years (Castetbon & Andreyeva, 2012; Laukkanen et al., 2017; Logan et al., 2011; Zaragas et al., 2013), with some of them arguing that children's level of biological maturation should also be considered to establish valid correlations (Musalek et al., 2017). On the other hand, other studies both in preschoolers (D'Hondt et al., 2009; Logan et al., 2011; Marinković, 2013; Morano et al., 2011; Okely et al., 2004) and school-age children (Cairney et al., 2005a, Cairney et al., 2010; Zhu et al., 2011) have shown a correlation between higher BMI scores and lower fundamental motor skill development or prevalence of DCD respectively, in comparison with typically weighted peers. Supporting these findings a recent systematic review found strong evidence that higher weight among school-age children is negatively associated with fundamental motor skill development and positively associated with motor difficulties in children, although it is not yet clear at what age this association first develops (Barnett et al., 2016). However, this association appears to be long-term, with long-term consequences reflected in increases in BMI and decreases in physical and motor skills (Cairney et al., 2010; Li et al., 2011; Rivilis et al. al., 2011; Tsiotra et al., 2009; Zhu et al., 2011). In general, motor skill development was negatively correlated with childhood obesity only for skills directly related to body weight (Castetbon, & Andreyeva, 2012; D'Hondt et al., 2011; Krombholz, 2013; Yang et al., 2015; Zhu et al., 2014), such as jumping and balance, while fine motor and ball skills do not appear to be affected (Barnett et al., 2016; Faught et al., 2013), although in other studies overweight and obese children performed worse in both gross and fine motor skills (D'Hondt et al., 2009). This inverse relationship between BMI and gross motor performance seems to be low among preschoolers but strengthens throughout childhood (Bonvin et al., 2012; Castetbon & Andreyeva, 2012; D'Hondt et al., 2011; Logan et al., 2011; Lopes et al., 2012; Nervik et al., 2011), and becomes more evident in school age children (D'Hondt et al., 2009; Graf et al., 2004; Okely et al., 2004; Southall et al., 2004). Therefore, body weight seemed to be a factor that may influence or be correlated with the occurrence of motor difficulties in preschoolers and should be addressed in future research.

Regarding the fifth hypothesis about the occurrence of motor difficulties in preschoolers living in rural and urban areas, the results of the present study showed no statistically significant differences. According to previous studies, geographic location, size (Mensink et al., 1997; Reeder et al., 1997), and population density in an area, as well as distance from urban centers, are some of the factors that may distinguish an urban area from a rural area, and their effects on motor development have been assessed (Niemistö et al., 2019). It has been supported that the acquisition and development of motor skills is directly influenced by the child's environment (Venetsanou & Kambas, 2010), however, the effect of place of residence on the development of motor and physical skills in preschoolers and school age-children has shown conflicting results (Parks et al., 2003). A previous study in Greece reported a correlation between environmental factors and preschoolers' motor development (Giagazoglou et al., 2007), with children living in urban areas outperforming children living in rural areas in fine motor skills, while children living in rural performing better in gross motor skills. Alongside these results, preschoolers living in rural areas were found to present with, better motor skills and greater participation in physical activities compared to children living in a large city (Niemistö et al., 2019). On the other hand, supporting the findings of the present study, no correlation was found between preschoolers' place of residence, physical fitness levels, and motor skill development (Engel-Yeger et al., 2010; Tsimeas et al., 2005). It should be noted that the present study took place in a small town in Northern Greece and in nearby villages in the district, so the conditions that distinguish an urban from a rural area may not have been met. In Greece, rural areas are defined as those with less than 5,000 inhabitants and low population density (Tambalis et al., 2011). In the present study, although this condition was confirmed, the total population of the prefecture was very low, which meant that rural areas were more similar than distinctly different from the urban center. The advantages of children living in a rural area over children living in an urban area have been confirmed for many domains of gross motor skills (Antunes et al., 2018; Cappellini et al., 2008; Sasso et al., 2018; Walhain et al., 2016) and motor skill development (Karkera et al., 2014; Tambalis et al., 2011). Therefore, it seems that the opportunities for physical activity provided by the child's environment influence his/her participation and, consequently, the level of his/her motor development; thus, rural versus urban living should be considered as a possible risk factor for the occurrence of motor difficulties in future research.

Finally, according to the sixth hypothesis, preschoolers' occurrence of motor difficulties differentiated in relation to hand preference. The results were not statistically significant; however, there were indications that right-handed preschoolers were less likely to have moderate or significant motor difficulties, compared to left-handed preschoolers: this is in agreement with previous literature regarding the higher prevalence of left-handed children in developmental disorders and DCD (Darvik, et al., 2018; Freitas et al., 2014; Goez & Zelnik, 2008). Regarding preschoolers, a previous study found that right-handed children scored higher than left-handed children on fine motor skills (Giagazoglou et al., 2001). Moreover, the negative impact of unstable handedness and left-handedness on children's motor performance has been confirmed in many studies (Cairney et al., 2008; Darvik et al., 2018; Flouris et al., 2005; Freitas et al., 2014; Goez & Zelnik, 2008; Markou et al., 2017; Rodger et al., 2003). However, in relation to preschoolers, some researchers argued that the process of handedness is not yet complete, so we cannot draw conclusions with certainty (Gabbard et al., 1993). More research is needed to explore the possible correlation between handedness and motor skill development, in order to allow for more targeted educational interventions. However, the results of the present study should be interpreted with caution.

In summary, the results of the present study confirmed the current literature which found the detection of motor difficulties in preschoolers feasible and useful (Dewey et al., 2011). The high prevalence of motor difficulties in this sample is consistent with similar studies and with the finding that DCD is a condition that appears to be present as early as age three. Given the negative impact of low motor performance on all areas of child development (Adi-Japha & Brestel, 2020; Alesi et al., 2019; Iversen et al., 2006; Kennedy-Behr et al., 2013; Mikami et al., 2020; Pike et al., 2008; Rodriguez et al., 2019; Rosenblum et al., 2017), early identification of motor difficulties can initiate early intervention and better prognosis for child development (Piek et al., 2012). Although an official identification of motor difficulties is not suggested before the age of five (APA, 2013), the assessment of fine and gross motor development from an early age is of great importance because it allows for the application of appropriate educational intervention based on each child's characteristics and motor difficulties. However, since statistically significant results were not obtained in this study, the effects of gender, age, BMI, handedness, and place of residence on the occurrence of motor difficulties in preschoolers, need further investigation.

This study holds significant importance regarding the occurrence of motor difficulties in preschoolers and the factors that could affect them. Given the dearth of research within this age band, the study addresses a critical gap in the existing knowledge. However, further research is needed to equip physical educators with valuable insights to apply developmentally appropriate physical education programs for preschoolers. Early physical education programs could prevent the engagement of the child in the vicious cycle of inactivity and all the secondary negative effects that could follow them later in life.

Conclusions

The results of this study suggested that motor difficulties in preschoolers are evident and could be assessed at an early age. The data confirmed a high prevalence of significant and moderate motor difficulties in preschool children however, an official identification of motor difficulties before the age of five should be avoided, thus the interpretation of these findings should be made with caution. Although factors such as gender, age, BMI, place of residence, and handedness did not seem to influence motor difficulties in preschool children, there were evidence that some of them could affect specific motor domains, such as hand dexterity, ball skills, and balance. Further research is encouraged aiming at investigating motor difficulties and possible risk factors affecting them. Given that an official diagnosis of DCD before the age of five is not suggested, it should be advisable for professionals in preschool education to assess motor difficulties to know the motor domains that the child needs early educational support. Developmentally appropriate physical education programs could be very useful for preschoolers to alleviate motor difficulties and prevent them from engaging in the vicious cycle of inactivity and be physically active later in their life.

Availability of data and materials: The data that support the findings of this study are available from the corresponding author (Olga Kechagia), upon reasonable request.

Competing Interests: There are no relevant financial, or non-financial competing interests to report.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

Acknowledgements

The authors appreciate the willingness and collaboration of parents and preschoolers and research assistants who were involved in the study.

IRB consent: The research study was approved by the Ministry of Education, Research and Religion, General Department of Primary and Secondary Education Department of Curriculum, Programs & Organization of P.E., Department A' Studies & Program Implementation

References

Adi-Japha, E., & Brestel, G. (2020). Motor skill learning with impaired transfer by children with Developmental Coordination Disorder. *Research in Developmental Disabilities, 103*, Article 103671. https://doi.org/10.1016/j.ridd.2020.103671

Alesi, M., Pecoraro, D., & Pepi, A. (2019). Executive functions in kindergarten children at risk for Developmental Coordination Disorder. *European Journal of Special Needs Education, 34*(3), 285–296. https://doi.org/10.1080/08856257.2018.1468635

Amador-Ruiz, S., Gutierrez, D., Martínez-Vizcaíno, V., Gulías-González, R., Pardo-Guijarro, M. J., & Sánchez-López, M. (2018). Motor competence levels and prevalence of developmental coordination disorder in Spanish children: The MOVI-KIDS study. *Journal of School Health, 88*(7), 538–546. https://doi.org/10.1111/josh.12639

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)*. American Psychiatric Pub.

Antunes, A. M., Freitas, D. L., Maia, J., Hedeker, D., Gouveia, É. R., Thomis, M., Lefevre, J., & Barnett, L. M. (2018). Motor performance, body fatness and environmental factors in preschool children. *Journal of Sports Sciences, 36*(20), 2289–2295. https://doi.org/10.1080/02640414.2018.1449410

Armitage, M., & Larkin, D. (1993). Laterality, motor asymmetry and clumsiness in children. *Human Movement Science, 12*(1–2), 155–177. https://doi.org/10.1016/0167-9457(93)90041-M

Bala, G., Golubović, Š., & Katić, R. (2010). Relations between handedness and motor abilities in preschool children. *Collegium Antropologicum, 34*(1), 69–75. https://hrcak.srce.hr/51730

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescent Health, 44*(3), 252–259. https://doi.org/10.1016/j.jadohealth.2008.07.004

Barnett, L. M., Lai, S. K., Veldman, S. L. C., Hardy, L. L., Cliff, D. P., Morgan, P. J., Zask, A., Lubans, D. R., Shultz, S. P., Ridgers, N. D., Rush, E., Brown, H. L., & Okely, A. D. (2016). Correlates of gross motor competence in children and adolescents: A systematic review and meta-analysis. *Sports Medicine, 46*(11), 1663–1688. https://doi.org/10.1007/s40279-016-0495-z

Beitel, P. A., & Mead, B. J. (1982). Bruininks-Oseretsky Test of Motor Proficiency: Further verification with 3- to 5-yr.-old children. *Perceptual and Motor Skills, 54*(1), 268–270. https://doi.org/10.2466/pms.1982.54.1.268

Blank, R., Smits-Engelsman, B., Polatajko, H., Wilson, P., & European Academy for Childhood Disability (2012). European Academy for Childhood Disability (EACD): Recommendations on the definition, diagnosis and intervention of Developmental Coordination Disorder (long version). *Developmental Medicine and Child Neurology, 54*(1), 1e–e7. https://doi.org/10.1111/j.1469-8749.2011.04175.x

Bonvin, A., Barral, J., Kakebeeke, T. H., Kriemler, S., Longchamp, A., Marques-Vidal, P., & Puder, J. J. (2012). Weight status and gender-related differences in motor skills and in child care-based physical activity in young children. *BMC Pediatrics, 12*(1), Article 23. https://doi.org/10.1186/1471-2431-12-23

Cairney, J., Hay, J. A., Faught, B. E., & Hawes, R. (2005a). Developmental Coordination Disorder and overweight and obesity in children aged 9–14 years. *International Journal of Obesity, 29*(4), 369–372. https://doi.org/10.1038/sj.ijo.0802893

Cairney, J., Hay, J., Faught, B., Mandigo, J., & Flouris, A. (2005b). Developmental Coordination Disorder, self-efficacy toward physical activity, and play: Does gender matter? *Adapted Physical Activity Quarterly, 22*(1), 67–82. https://doi.org/10.1123/apaq.22.1.67

Cairney, J., Hay, J. A., Veldhuizen, S., Missiuna, C., Mahlberg, N., & Faught, B. E. (2010). Trajectories of relative weight and waist circumference among children with and without Developmental Coordination Disorder. *Canadian Medical Association Journal, 182*, 1167–1172. https://doi.org/10.1503/cmaj.091454

Cairney, J., Hay, J., Veldhuizen, S., & Faught, B. (2011). Assessment of body composition using whole body air-displacement plethysmography in children with and without Developmental Coordination Disorder. *Research in Developmental Disabilities, 32*(2), 830–835. https://doi.org/10.1016/j.ridd.2010.10.011

Cairney, J., & King-Dowling, S. (2016). Developmental Coordination Disorder. In J. L. Matson (Ed.), *Comorbid conditions among children with autism spectrum disorders* (pp. 303–322). Springer International Publishing https://doi.org/10.1007/978-3-319-19183-6_13

Cairney, J., & Veldhuizen, S. (2013). Is developmental coordination disorder a fundamental cause of inactivity and poor health-related fitness in children? *Developmental Medicine and Child Neurology, 55*(Suppl. 4), 55–58. https://doi.org/10.1111/dmcn.12308

Cairney, J., Schmidt, L. A., Veldhuizen, S., Kurdyak, P., Hay, J., & Faught, B. E. (2008). Left-handedness and developmental coordination disorder. *The Canadian Journal of Psychiatry, 53*(10), 696–699. https://doi.org/10.1177/070674370805301009

Cantell, M., & Crawford, S. G. (2008). Physical fitness and health indices in children, adolescents and adults with high or low motor competence. *Human Movement Science, 27*(2), 344–362. https://doi.org/10.1016/j.humov.2008.02.007

Cappellini, A. C., Mancini, S., Zuffellato, S., Bini, F., Polcaro, P., Conti, A. A., Molino Lova, R., & Macchi, C. (2008). Environmental effects on school age child psychomotricity. *Minerva Pediatrica, 60*(3), 277–284. https://www.minervamedica.it/en/journals/minerva-pediatrics/issue.php?cod=R15Y2008N03

Castetbon, K., & Andreyeva, T. (2012). Obesity and motor skills among 4 to 6-year-old children in the United States: Nationally-representative surveys. *BMC Pediatrics, 12*(1), Article 28. https://doi.org/10.1186/1471-2431-12-28

Causgrove Dunn, J., & Dunn, J. G. (2006). Psychosocial determinants of physical education behavior in children with movement difficulties. *Adapted Physical Activity Quarterly, 23*(3), 293–309. https://doi.org/10.1123/apaq.23.3.293

Chambers, M. E., & Sugden, D. A. (2002). The identification and assessment of young children with movement difficulties. *International Journal of Early Years Education, 10*(3), 157–176. https://doi.org/10.1080/0966976022000044717

Chow, S. M., Henderson, S. E., & Barnett, A. L. (2001). The Movement Assessment Battery for Children: A comparison of 4-year-old to 6-year-old children from Hong Kong and the United States. *The American Journal of Occupational Therapy: Official Publication of the American Occupational Therapy Association, 55*(1), 55–61. https://doi.org/10.5014/ajot.55.1.55

Chow, S. M., Hsu, Y. W., Henderson, S. E., Barnett, A. L., & Lo, S. K. (2006). The movement ABC: A cross-cultural comparison of preschool children from Hong Kong, Taiwan, and the USA. *Adapted Physical Activity Quarterly, 23*(1), 31–48. https://doi.org/10.1123/apaq.23.1.31

Cleland, F. E., & Gallahue, D. L. (1993). Young children's divergent movement ability. *Perceptual and Motor Skills, 77*(2), 535–544. https://doi.org/10.2466/pms.1993.77.2.535

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Earlbaum Associates.

Cratty, B.J. (1994). *Clumsy child. Syndromes, descriptions, evaluation and remediation*. Harwood Academic Publishers.

D' Hondt, E., Gentier, I., Deforche, B., Tanghe, A., De Bourdeaudhuij, I., & Lenoir, M. (2011). Weight loss and improved gross motor coordination in children as a result of multidisciplinary residential obesity treatment. *Obesity, 19*(10), 1999–2005. https://doi.org/10.1038/oby.2011.150

D'Hondt, E., Deforche, B., De Bourdeaudhuij, I., & Lenoir, M. (2009). Relationship between motor skill and body mass index in 5-to 10-year-old children. *Adapted Physical Activity Quarterly, 26*(1), 21–37. https://doi.org/10.1123/apaq.26.1.21

Dana, A., Habibi, Z., Hashemi, M., & Asghari, A. (2011). A Description and comparison of anthropometrical and physical fitness characteristics in urban and rural 7-11 years old boys and girls in Golestan Province. Iran. *Middle-East Journal of Scientific Research, 8*(1), 231–236. https://doi.org/10.2139/ssrn.3947479

Darrah, J., Senthilselvan, A., & Magill-Evans, J. (2009). Trajectories of serial motor scores of typically developing children: Implications for clinical decision making. *Infant Behavior and Development, 32*(1), 72–78. https://doi.org/10.1016/j.infbeh.2008.10.001

Darvik, M., Lorås, H., & Pedersen, A. V. (2018). The prevalence of left-handedness is higher among individuals with Developmental Coordination Disorder than in the general population. *Frontiers in Psychology, 9*, Article 1948. https://doi.org/10.3389/fpsyg.2018.01948

Della Barba, P. C. S., Luiz, E. M., Pinheiro, R. C., & Lourenço, G. F. (2017). Prevalence of Developmental Coordination Disorder signs in children 5 to 14 years in São Carlos. *Motricidade, 13*(3), 22–30. http://dx.doi.org/10.6063/motricidade.10058

Dewey, D., Creighton, D. E., Heath, J. A., Wilson, B. N., Anseeuw-Deeks, D., Crawford, S. G., & Sauve, R. (2011). Assessment of Developmental Coordination Disorder in children born with extremely low birth weights. *Developmental Neuropsychology, 36*(1), 42–56. https://doi.org/10.1080/87565641.2011.540535

Dewey, D., Kaplan, B. J., Crawford, S. G., & Wilson, B. N. (2002). Developmental Coordination Disorder: Associated problems in attention, learning, and psychosocial adjustment. *Human Movement Science, 21*(5–6), 905–918. https://doi.org/10.1016/S0167-9457(02)00163-X

Dourou, E., Komessariou, A., Riga, V., & Lavidas, K. (2017). Assessment of gross and fine motor skills in preschool children using the Peabody Developmental Motor Scales Instrument. *European Psychomotricity Journal, 9*(1), 89–113. https://psychomotor.gr/

Dussart, G. (1994). Identifying the clumsy child in school: An exploratory study. *British Journal of Special Education, 21*(2), 81–86. https://eric.ed.gov/?id=EJ489458

Ellinoudis, T., Kourtessis, T., Kiparissis, M., Kampas, A., & Mavromatis, G. (2008). Movement Assessment Battery for Children (MABC): Measuring the construct validity for Greece in a sample of elementary school aged children. *International Journal of Health Science, 1*(2), 56–60.

Engel-Yeger, B., Rosenblum, S., & Josman, N. (2010). Movement Assessment Battery for Children (M-ABC): Establishing construct validity for Israeli children. *Research in Developmental Disabilities, 31*(1), 87–96. https://doi.org/10.1016/j.ridd.2009.08.001

Faught, B. E., Demetriades, S., Hay, J., & Cairney, J. (2013). Does relative body fat influence the Movement ABC-2 assessment in children with and without developmental coordination disorder? *Research in Developmental Disabilities, 34*(12), 4433–4438. https://doi.org/10.1016/j.ridd.2013.09.016

Flouris, A. D., Faught, B. E., Hay, J., & Cairney, J. (2005). Exploring the origins of developmental disorders. *Developmental Medicine and Child Neurology, 47*(7), 436. https://doi.org/10.1017/S0012162205000848

Freitas, C., Vasconcelos, M. O., & Botelho, M. (2014). Handedness and Developmental Coordination Disorder in Portuguese children: Study with the M-ABC test. *Laterality: Asymmetries of Body, Brain and Cognition, 19*(6), 655–676. https://doi.org/10.1080/1357650X.2014.897349

Gabbard, C., Hart, S., & Kanipe, D. (1993). Hand preference consistency and fine motor performance in young children. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 29*(4),

749–753. https://doi.org/10.1016/s0010-9452(13)80295-x
Gallahue, D. L., Ozmun, J. C., & Goodway, J. (2006). *Understanding motor development: Infants, children, adolescents, adults*. McGraw-Hill.
Giagazoglou, P., Fotiadou, E., Angelopoulou, N., Tsikoulas, J., & Tsimaras, V. (2001). Gross and fine motor skills of left-handed preschool children. *Perceptual and Motor Skills, 92*(Suppl. 3), 1122–1128. https://doi.org/10.2466/pms.2001.92.3c.1122
Giagazoglou, P., Kabitsis, N., Kokaridas, D., Zaragas, C., Katartzi, E., & Kabitsis, C. (2011). The Movement Assessment Battery in Greek preschoolers: The impact of age, gender, birth order, and physical activity on motor outcome. *Research in Developmental Disabilities, 32*(6), 2577–2582. https://doi.org/10.1016/j.ridd.2011.06.020
Giagazoglou, P., Kyparos, A., Fotiadou, E., & Angelopoulou, N. (2007) The effect of residence area and mother's education on motor development of preschool aged children in Greece. *Early Child Development and Care, 177*(5), 479–492. https://doi.org/10.1080/03004430600563786
Gidley-Larson, J., Mostofsky, S., Goldberg, M., Cutting. L., Denckla, M., & Mahone, E. (2007). Effects of gender and age on motor exam in typically developing children. *Developmental Neuropsychology, 32*, 543–562. https://doi.org/10.1080/87565640701361013
Goez, H., & Zelnik, N. (2008). Handedness in patients with Developmental Coordination Disorder. *Journal of Child Neurology, 23*(2), 151–154. https://doi.org/10.1177/0883073807307978
Graf, C., Koch, B., Kretschmann-Kandel, E., Falkowski, G., Christ, H., Coburger, S., Lehmacher, W., Bjarnason-Wehrens, B., Platen, P., Tokarski, W., & Predel, H. G. (2004). Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-project). *International Journal of Obesity, 28*(1), 22–26. https://doi.org/10.1038/sj.ijo.0802428
Green, D., Lingam, R., Mattocks, C., Riddoch, C., Ness, A., & Emond, A. (2011). The risk of reduced physical activity in children with probable Developmental Coordination Disorder: A prospective longitudinal study. *Research in Developmental Disabilities, 32*(4), 1332–1342. https://doi.org/10.1016/j.ridd.2011.01.04
Gwynne, K., & Blick, B. (2004). Motor performance checklist for 5-year-olds: A tool for identifying children at risk of developmental co-ordination disorder. *Journal of Paediatrics and Child Health, 40*(7), 369–373. https://doi.org/10.1111/j.1440-1754.2004.00404.x
Hadders-Algra, M. (2000). The neuronal group selection theory: promising principles for understanding and treating developmental motor disorders. *Developmental Medicine and Child Neurology, 42*(10), 707–715. https://doi.org/10.1017/s0012162200001316
Henderson, S. E., Sugden, D. A., & Barnett, A. L. (2007). *Movement Assessment Battery for Children-2 Second Edition*. The Psychological Corporation.
Hirata, S., Kita, Y., Yasunaga, M., Suzuki, K., Okumura, Y., Okuzumi, H., Hosobuchi, T., Kokubun, M., Inagaki, M., & Nakai, A. (2018). Applicability of the Movement Assessment Battery for Children (MABC-2) for Japanese children aged 3–6 years: A preliminary investigation emphasizing internal consistency and factorial validity. *Frontiers in Psychology, 9*, Article 1452. https://doi.org/10.3389/fpsyg.2018.01452
Hulteen, R. M., Morgan, P. J., Barnett, L. M., Stodden, D. F., & Lubans, D. R. (2018). Development of foundational movement skills: A conceptual model for physical activity across the lifespan. *Sports Medicine, 48*(7), 1533–1540. https://doi.org/10.1007/s40279-018-0892-6
Iversen, S., Knivsberg, A. M., Ellertsen, B., Nødland, M., & Larsen, T. B. (2006). Motor coordination difficulties in 5–6-year-old children with severe behavioral and emotional problems. *Emotional and Behavioral Difficulties, 11*(3), 169–185. https://doi.org/10.1080/13632750600833817
Jelovčan, G., & Zurc, J. (2016). Preschool children's results in movement ABC tests: Differences between girls and boys in movement deficit. *Annales Kinesiologiae, 7*(1), 3–19. http://ojs.zrs-kp.si/index.php/AK/article/view/114
Jin, H., Gu, G., Qin, Z., & Ma, Y. (2015). A population study of parenting and biological risk factors for

children's Developmental Coordination Disorder. *Journal of Child and Adolescent Behavior, 3*(6). https://doi.org/10.4172/2375-4494.1000260

Jones, A. P., Coombes, E. G., Griffin, S. J., & van Sluijs, E. M. (2009). Environmental supportiveness for physical activity in English schoolchildren: A study using Global Positioning Systems. *International Journal of Behavioral Nutrition and Physical Activity, 6*(1), Article 42. https://doi.org/10.1186/1479-5868-6-42

Junaid, K. A., & Fellowes, S. (2006). Gender differences in the attainment of motor skills on the movement assessment battery for children. *Physical & Occupational Therapy in Pediatrics, 26*(1–2), 5–11.

Kambas, A., Venetsanou, F., Giannakidou, D., Fatouros, I. G., Avloniti, A., Chatzinikolaou, A., Draganidis, D., & Zimmer, R. (2012). The Motor-Proficiency-Test for children between 4 and 6 years of age (MOT 4–6): An investigation of its suitability in Greece. *Research in Developmental Disabilities, 33*(5), 1626–1632. https://doi.org/10.1016/j.ridd.2012.04.002

Karkera, A., Swaminathan, N., Pais, S. M., Vishal, K., & Rai, S. (2014). Physical fitness and activity levels among urban school children and their rural counterparts. *The Indian Journal of Pediatrics, 81*(4), 356–361. https://doi.org/10.1007/s12098-013-1033-8

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

Kennedy-Behr, A., Rodger, S., & Mickan, S. (2013). A comparison of the play skills of preschool children with and without Developmental Coordination Disorder. *OTJR: Occupation, Participation and Health, 33*(4), 198–208. https://doi.org/10.3928/15394492-20130912-03

Kita, Y., Suzuki, K., Hirata, S., Sakihara, K., Inagaki, M., & Nakai, A. (2016). Applicability of the Movement Assessment Battery for Children-to Japanese children: A study of the Age Band 2. *Brain and Development, 38*(8), 706–713. https://doi.org/10.1016/j.braindev.2016.02.012

Kokštejn, J., Musálek, M., Šťastný, P., & Golas, A. (2017a). Fundamental motor skills of Czech children at the end of the preschool period. *Acta Gymnica, 47*(4), 193–200. https://doi.org/10.5507/ag.2017.024

Kokštejn, J., Musálek, M., & Tufano, J. J. (2017b). Are sex differences in fundamental motor skills uniform throughout the entire preschool period? *PLoS One, 12*(4), 1–10. https://doi.org/10.1371/journal.pone.0176556

Kourtessis, T., Tsougou, E., Maheridou, M., Tsigilis, N., Psalti, M., & Kioumourtzoglou, E. (2008). Developmental Coordination Disorder in early childhood-A preliminary epidemiological study in Greek schools. *The International Journal of Medicine, 1*(2), 95–99.

Kriemler, S., Manser-Wenger, S., Zahner, L., Braun-Fahrländer, C., Schindler, C., & Puder, J. J. (2008). Reduced cardiorespiratory fitness, low physical activity and an urban environment are independently associated with increased cardiovascular risk in children. *Diabetologia, 51*(8), 1408–1415. https://doi.org/10.1007/s00125-008-1067-z

Krombholz, H. (2013). Motor and cognitive performance of overweight preschool children. *Perceptual and Motor Skills, 116*(1), 40–57. https://doi.org/10.2466/22.25.PMS.116.1.40-57

Landgren, M., Kjellman, B., & Gillberg, C. (2000). Deficits in attention, motor control and perception (DAMP): A simplified school entry examination. *Acta Paediatrica, 89*(3), 302–309. https://doi.org/10.1111/j.1651-2227.2000.tb01332.x

Largo, R. H., Fischer, J. E., & Rousson, V. (2003). Neuromotor development from kindergarten age to adolescence: Developmental course and variability. *Swiss Medical Weekly, 133*(13–14), 193–200. https://doi.org/10.5167/uzh-34720

Larkin, D., & Rakimov, B. (2006). Children with motor learning difficulties in the school environment. *ACHPER Australia Healthy Lifestyles Journal, 53*(3–4), 5–9. https://doi.org/10.3316/aeipt.157669

Laukkanen, A., Pesola, A. J., Finni, T., & Sääkslahti, A. (2017). Body mass index in the early years in relation to motor coordination at the age of 5–7 years. *Sports, 5*(3), Article 49.

https://doi.org/10.3390/sports5030049
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. https://doi.org/10.1016/j.ridd.2011.04.009
Livesey, D., Coleman, R., & Piek, J. (2007). Performance on the Movement Assessment Battery for children by Australian 3-to 5-year-old children. *Child: Care, Health and Development, 33*(6), 713–719. https://doi.org/10.1111/j.1365-2214.2007.00733.x
Logan, S. W., Scrabis-Fletcher, K., Modlesky, C., & Getchell, N. (2011). The relationship between motor skill proficiency and body mass index in preschool children. *Research Quarterly for Exercise and Sport, 82*(3), 442–448. https://doi.org/10.1080/02701367.2011.10599776
Lopes, V. P., Stodden, D. F., Bianchi, M. M., Maia, J. A., & Rodrigues, L. P. (2012). Correlation between BMI and motor coordination in children. *Journal of Science and Medicine in Sport, 15*(1), 38–43. https://doi.org/10.1016/j.jsams.2011.07.005
Loucaides, CA., Plotnikoff, R., & Bercovitz, K. (2007). Differences in the correlates of physical activity between urban and rural Canadian youth. *Journal of School Health, 77*(4) 164–170. https://doi.org/10.1111/j.1746-1561.2007.00187.x
Malina, R. M. (2004). Motor development during infancy and early childhood: Overview and suggested directions for research. *International Journal of Sport and Health Science, 2,* 50–66. https://doi.org/10.5432/ijshs.2.50
Mamalakis, G., Kafatos, A., Manios, Y., Anagnostopoulou, T., & Apostolaki, I. (2000). Obesity indices in a cohort of primary school children in Crete: A six-year prospective study. *International Journal of Obesity, 24*(6), 765–771. https://doi.org/10.1038/sj.ijo.0801223
Markou, P., Ahtam, B., & Papadatou-Pastou, M. (2017). Elevated levels of atypical handedness in Autism: Meta-analyses. *Neuropsychology Review, 27*, 258–283. https://doi.org/10.1007/s11065-017-9354-4
Mensink, G. B., Loose, N., & Oomen, C. M. (1997). Physical activity and its association with other lifestyle factors. *European Journal of Epidemiology, 13*(7), 771–778. https://doi.org/10.1023/a:1007474220830
Mercê, C., Branco, M., Fernandes, O., & Catela, D. (2019). Prevalence of Developmental Coordination Disorder in Rio Maior and São João da Ribeira in children with 3 and 4 years old. *Medi@ções–Revista OnLine da Escola Superior de Educação do Instituto Politécnico de Setúbal, 7*(2), 179–192. https://mediacoes.ese.ips.pt/index.php/mediacoesonline/article/view/132
Mikami, M., Hirota, T., Takahashi, M., Adachi, M., Saito, M., Koeda, S., Yoshida, K., Sakamoto, Y., Kato, S., Nakamura, K., & Yamada, J. (2020). Atypical sensory processing profiles and their associations with motor problems in preschoolers with Developmental Coordination Disorder. *Child Psychiatry & Human Development, 52*(2), 311–320. https://doi.org/10.1007/s10578-020-01013-5
Missiuna, C., Rivard, L., & Pollock, N. (2011). *Children with Developmental Coordination Disorder: At home, at school, and in the community*. CanChild Centre for Childhood Disability: McMaster University, Hamilton.
Marinković, D. (2013). The relationship between coordination, motor abilities and anthropometric characteristics of preschool girls. *Exercise and Quality of Life, 5*(1), 43–52. 10.5937/exquli1301043M
Monastiridi, S. G., Katartzi, E. S., Kontou, M. G., Kourtessis, T., & Vlachopoulos, S. (2020). Positive relations of physical fitness and exercise intervention programs with motor competence and health related quality of life in Developmental Coordination Disorder: A systematic review. *European Journal of Physical Education and Sport Science, 6*(2), 1–26. https://doi.org/10.5281/zenodo.3701897
Morano, M., Colella, D., & Caroli, M. (2011). Gross motor skill performance in a sample of overweight and non-overweight preschool children. *International Journal of Pediatric Obesity: IJPO: An Official Journal of the International Association for the Study of Obesity, 6*(Suppl. 2), 42–46. https://doi.org/10.3109/17477166.2011.613665

Mori, S., Iteya, M., & Gabbard, C. (2007). Hand preference consistency and simple rhythmic bimanual coordination in preschool children. *Perceptual and Motor skills, 104*(3), 792–798. https://doi.org/10.2466/pms.104.3.792-79

Musalek, M., Kokstejn, J., Papez, P., Scheffler, C., Mumm, R., Czernitzki, A. F., & Koziel, S. (2017). Impact of normal weight obesity on fundamental motor skills in pre-school children aged 3 to 6 years. *Anthropologischer Anzeiger: Bericht uber die biologisch-anthropologische Literatur, 74*(3), 203–212. https://doi.org/10.1127/anthranz/2017/0752

Nelson, J. K., Thomas, J. R., Nelson, K. R., & Abraham, P. C. (1986). Gender differences in children's throwing performance: Biology and environment. *Research Quarterly for Exercise and Sport, 57*(4), 280–287.

Nervik, D., Martin, K., Rundquist, P., & Cleland, J. (2011). The relationship between Body Mass Index and gross motor development in children aged 3 to 5 years. *Pediatric Physical Therapy, 23*(2), 144–148. https://doi.org/10.1097/PEP.0b013e318218d356

Niemistö, D., Finni, T., Haapala, E. A., Cantell, M., Korhonen, E., & Sääkslahti, A. (2019). Environmental correlates of motor competence in children—The skilled kids study. *International Journal of Environmental Research and Public Health, 16*(11), Article 1989. https://doi.org/10.3390/ijerph16111989

Nordbye-Nielsen, K., & Kesmodel, U. S. (2014). Parental Questionnaire as a screening instrument for motor function at age five. *Danish Medical Journal, 61*(12), Article A4976.

Okely, A. D., Booth, M. L., & Chey, T. (2004). Relationships between body composition and fundamental movement skills among children and adolescents. *Research Quarterly for Exercise and Sport, 75*(3), 238–247. https://doi.org/10.1080/02701367.2004.10609157

Olesen, L. G., Kristensen, P. L., Ried-Larsen, M., Grøntved, A., & Froberg, K. (2014). Physical activity and motor skills in children attending 43 preschools: a cross-sectional study. *BMC Pediatrics, 14*, 1–11. https://doi.org/10.1186/1471-2431-14-229

Özdirenç, M., Özcan, A., Akin, F., & Gelecek, N. (2005). Physical fitness in rural children compared with urban children in Turkey. *Pediatrics International, 47*(1), 26–31.

Papadopoulos, D., Fatouros, I., & Taxildaris, K. (2008). Motor proficiency, physical activity and Body Mass Index in preschool aged children. *European Psychomotricity Journal, 1*(1), 61–66.

Parks, S. E., Housemann, R. A., & Brownson, R. C. (2003). Differential correlates of physical activity in urban and rural adults of various socioeconomic backgrounds in the United States. *Journal of Epidemiology & Community Health, 57*(1), 29–35. https://doi.org/10.1136/jech.57.1.29

Piek, J. P., Bradbury, G. S., Elsley, S. C., & Tate, L. (2008). Motor coordination and social–emotional behavior in preschool-aged children. *International Journal of Disability, Development and Education, 55*(2), 143–151. https://doi.org/10.1080/10349120802033592

Piek, J. P., Hands, B., & Licari, M. K. (2012). Assessment of motor functioning in the preschool period. *Neuropsychology Review, 22*(4), 402–413. https://doi.org/10.1007/s11065-012-9211-4

Puciato, D., Mynarski, W., Rozpara, M., Borysiuk, Z., &Szyguła, R. (2011). Motor Development of children and adolescents aged 8-16 years in view of their somatic build and objective quality of life of their families. *Journal of Human Kinetics, 28*, 45–53. https://doi.org/10.2478/v10078-011-0021-1

Pulzi, W., & Rodrigues, G. M. (2015). Coordination Development Disorder: A literature review. *Brazilian Journal of Special Education, 21*(3), 433–444. https://cpe.psychopen.eu/index.php/cpe/article/view/4165

Reeder, B. A., Chen, Y., Macdonald, S. M., Angel, A., & Sweet, L. (1997). Regional and rural-urban differences in obesity in Canada. Canadian Heart Health Surveys Research Group. *CMAJ: Canadian Medical Association journal / Journal de l'Association Medicale Canadienne, 157*(Suppl. 1), S10–S16.

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. https://doi.org/10.1016/j.ridd.2011.01.017

Roberts, D., Veneri, D., Decker, R., & Gannotti, M. (2012). Weight status and gross motor skill in kindergarten children. *Pediatric Physical Therapy, 24*(4), 353–360. https://doi.org/10.1097/PEP.0b013e3182680f19

Rodger, S., Ziviani, J., Watter, P., Ozanne, A., Woodyatt, G., & Springfeld, E. (2003). Motor and functional skills of children with Developmental Coordination Disorder: A pilot investigation of measurement issues. *Human Movement Science, 22*, 461–478. https://doi.org/10.1016/j.humov.2003.09.004

Rodriguez, M. C., Wade, T. J., Veldhuizen, S., Missiuna, C., Timmons, B., & Cairney, J. (2019). Emotional and behavioral problems in 4-and 5-year-old children with and without motor delays. *Frontiers in Pediatrics, 7,* Article 474. https://doi.org/10.3389/fped.2019.00474

Rosenblum, S., Waissman, P., & Diamond, G. W. (2017). Identifying play characteristics of pre-school children with Developmental Coordination Disorder via parental questionnaires. *Human Movement Science, 53,* 5–15. https://doi.org/10.1016/j.humov.2016.11.003

Saraiva, L., Rodrigues, L. P., Cordovil, R., & Barreiros, J. (2013). Influence of age, sex and somatic variables on the motor performance of pre-school children. *Annals of Human Biology, 40*(5), 444–450. https://doi.org/10.3109/03014460.2013.802012

Sasso, R. R, Graup, S., Lara, S., de Souza B., R., dos Santos Chiquetti, E. M., & de Sá, M. V. (2018). Motor development of children in rural and urban areas: A comparative study. *Science & Health, 11*(3), 151–157.

Schott, N., Alof, V., Hultsch, D., & Meermann, D. (2007). Physical fitness in children with Developmental Coordination Disorder. *Research Quarterly for Exercise and Sport, 78*(5), 438–450. https://doi.org/10.1080/02701367.2007.10599444

Serbetar, I., Loftesnes, J. M., & Mamen, A. (2019). Reliability and structural validity of the Movement Assessment Battery for Children-2 in Croatian preschool children. *Sports, 7*(12), Article 248. https://doi.org/10.3390/sports7120248

Sigmundsson, H., & Rostoft, M. S. (2003). Motor development: Exploring the motor competence of 4-year-old Norwegian children. *Scandinavian Journal of Educational Research, 47*(4), 451–459. https://doi.org/10.1080/00313830308588

Simen-Kapeu, A., Kuhle, S., & Veugelers, P. J. (2010). Geographic differences in childhood overweight, physical activity, nutrition and neighborhood facilities: Implications for prevention. *Canadian Journal of Public Health, 101*(2), 128–132. https://doi.org/10.1007/BF03404357

Singh, D. K. A., Rahman, N. N. A. A., Rajikan, R., Zainudin, A., Nordin, N. A. M., Karim, Z. A., & Yee, Y. H. (2015). Balance and motor skills among preschool children aged 3 to 4 years old. *Malaysian Journal of Medicine and Health Sciences, 11*(1), 63–68.

Southall, J. E., Okely, A. D., & Steele, J. R. (2004). Actual and Perceived Physical Competence in Overweight and Nonoverweight Children. *Pediatric Exercise Science, 16*(1), 15–24. https://doi.org/10.1123/pes.16.1.15

Spessato, B. C., Gabbard, C., Valentini, N., & Rudisill, M. (2012). Gender differences in Brazilian children's fundamental movement skill performance. *Early Child Development and Care, 183*(7), 916–923. https://doi.org/10.1080/03004430.2012.689761

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

Suliga, E. (2009). Socio-economic differentiation of the growth and the dietary intake of Polish boys aged 7–16 years. *Annals of Human Biology, 36*(2), 199–210. https://doi.org/10.1080/03014460802698872

Tambalis, K. D., Panagiotakos, D. B., & Sidossis, L. S. (2011). Greek children living in rural areas are heavier but fitter compared to their urban counterparts: A comparative, time-series (1997–2008) analysis. *The Journal of Rural Health, 27*(3), 270–277. https://doi.org/10.1111/j.1748-0361.2010.00346.x

Thelen, E. (1995). Motor development: A new synthesis. *American Psychologist, 50*(2), 79–95. https://doi.org/10.1037/0003-066X.50.2.79

Thomas, J. R., & French, K. E. (1985). Gender differences across age in motor performance: A meta-analysis. *Psychological Bulletin, 98*(2), 260–282. https://doi.org/10.1037/0033-2909.98.2.260

Thomas, P., Peabody, J., Turnier, V., & Clark, R. H. (2000). A new look at intrauterine growth and the impact of race, altitude, and gender. *Pediatrics, 106*(2), E21. https://doi.org/10.1542/peds.106.2.e21

Tsimeas, P. D., Tsiokanos, A. L., Koutedakis, Y., Tsigilis, N., & Kellis, S. (2005). Does living in urban or rural settings affect aspects of physical fitness in children? An allometric approach. *British Journal of Sports Medicine, 39*(9), 671–674. https://doi.org/10.1136/bjsm.2004.017384

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

Tsiotra, G. D., Nevill, A. M., Lane, A. M., & Koutedakis, Y. (2009). Physical fitness and developmental coordination disorder in Greek children. *Pediatric Exercise Science, 21*(2), 186–195. https://doi.org/10.1123/pes.21.2.186

Valentini, N. C., Coutinho, M. T. C., Pansera, S. M., Santos, V. A. P. D., Vieira, J. L. L., Ramalho, M. H., & Oliveira, M. A. D. (2012). Prevalence of motor deficits and Developmental Coordination Disorders in children from South Brazil. *Revista Paulista de Pediatria, 30*(3), 377–384. https://doi.org/10.1590/S0103-05822012000300011

Valentini, N. C., Ramalho, M. H., & Oliveira, M. A. (2014). Movement Assessment Battery for Children-2: Translation, reliability, and validity for Brazilian children. *Research in Developmental Disabilities, 35*(3), 733–740. https://doi.org/10.1016/j.ridd.2013.10.028

Van Waelvelde, H., Peersman, W., Lenoir, M., Engelsman, B. C. S., & Henderson, S. E. (2008). The Movement Assessment Battery for Children: Similarities and differences between 4-and 5-year-old children from Flanders and the United States. *Pediatric Physical Therapy, 20*(1), 30–38. https://doi.org/10.1097/PEP.0b013e31815ee2b2

Venetsanou, F., & Kambas, A. (2010). Environmental factors affecting preschoolers' motor development. *Early Childhood Education Journal, 37*(4), 319–327. https://doi.org/10.1007/s10643-009-0350-z

Venetsanou, F., & Kambas, A. (2011). The effects of age and gender on balance skills in preschool children. *Facta Universitatis-Series: Physical Education and Sport, 9*(1), 81–90.

Venetsanou, F., & Kambas, A. (2016). Motor proficiency in young children: A closer look at potential gender differences. *Sage Open, 6*(1). https://doi.org/10.1177/2158244015626226

Venetsanou, F., Kambas, A., Ellinoudis, T., Fatouros, I., Giannakidou, D., & Kourtessis, T. (2011). Can the Movement Assessment Battery for Children-Test be the "gold standard" for the motor assessment of children with Developmental Coordination Disorder? *Research in Developmental Disabilities, 32*(1), 1–10. https://doi.org/10.1016/j.ridd.2010.09.006

Venter, A., Pienaar, A. E., & Coetzee, D. (2015). Extent and nature of motor difficulties based on age, ethnicity, gender and socio-economic status in a selected group of three-to five-year-old children. *South African Journal for Research in Sport, Physical Education and Recreation, 37*(3), 169–183. https://doi.org/10520/EJC181040

Vlachos, F., Papadimitriou, A., & Bonoti, F. (2014). An investigation of age and gender differences in preschool children's specific motor skills. *European Psychomotricity Journal, 6*(1), 16–18.

Walhain, F., Van Gorp, M., Lamur, K. S., Veeger, D. H., & Ledebt, A. (2016). Health-related fitness, motor coordination, and physical and sedentary activities of urban and rural children in Suriname. *Journal of Physical Activity and Health, 13*(10), 1035–1041. https://doi.org/10.1123/jpah.2015-0445

Wall, A. T. (2004). The developmental skill-learning gap hypothesis: Implications for children with movement difficulties. *Adapted Physical Activity Quarterly, 21*(3), 197–218. https://doi.org/10.1123/apaq.21.3.197

Wang, J. H., Wu, M. C., & Chang, H. H. (2013). Urban-rural disparity in physical fitness of elementary schoolchildren in Taiwan. *Pediatrics International, 55*(3), 346–354. https://doi.org/10.1111/ped.12044

Williams, H. G., Pfeiffer, K. A., O'Neill, J. R., Dowda, M., McIver, K. L., Brown, W. H., & Pate, R. R. (2008). Motor skill performance and physical activity in preschool children. *Obesity, 16*(6), 1421–1426. https://doi.org/10.1038/oby.2008.214

Wright, H. C., & Sugden, D. A. (1998). A school-based intervention program for children with Developmental Coordination Disorder. *European Journal of Physical Education, 3*(1), 35–50. https://doi.org/10.1080/1740898980030104

Yang, S. C., Lin, S. J., & Tsai, C. Y. (2015). Effect of sex, age, and BMI on the development of locomotor skills and object control skills among preschool children. *Perceptual and Motor Skills, 121*(3), 873–888. https://doi.org/10.2466/10.PMS.121c29x0

Zachopoulou, E., & Makri, A. (2005). A developmental perspective of divergent movement ability in early young children. *Early Child Development and Care, 175*(1), 85–95. https://doi.org/10.1080/0300443042000230401

Zaragas, C., Tsitsanoudi-Mallidi, N., & Aggelaki, A. (2013). Motor education and vocabulary development of arithmetical and geometrical concepts in kindergarten and primary education. In *Language learning and assessment—Challenges and implications* (pp. 89–111). Untested Ideas Research Center.

Zaragas, H. I., & Gajoya, D. N. (2019). Assessing motor development with two different tests in preschool children. *Research in Education, 8*(1), 145–162. https://doi.org/10.12681/hjre.20808

Zhu, Y. C., Cairney, J., Li, Y. C., Chen, W. Y., Chen, F. C., & Wu, S. K. (2014). High risk for obesity in children with a subtype of developmental coordination disorder. *Research in Developmental Disabilities, 35*(7), 1727–1733. https://doi.org/10.1016/j.ridd.2014.02.020

Zhu, Y. C., Wu, S. K., & Cairney, J. (2011). Obesity and motor coordination ability in Taiwanese children with and without Developmental Coordination Disorder. *Research in Developmental Disabilities, 32*(2), 801–807. https://doi.org/10.1016/j.ridd.2010.10.020

Olga Kechagia is a Physical Education Teacher in General Hospital of Thessaloniki G. Papanikolaou. She holds a BSc in Physical Education and Sport Science from Aristotle University of Thessaloniki, a MSc in Human Performance and Health, with a specialization in Adapted Physical Activity, from the Faculty of Physical Education and Sport Science at Aristotle University of Thessaloniki, Greece, and a MSc in Clinical Exercise and Health Technology Applications from the Faculty of Physical Education and Sport Science at Democritus University of Thrace. She has a long professional experience in the field of physical education and adapted physical exercise. Her research interests involve the assessment of children's and adolescents' motor skills and the implementation of appropriate motor interventions, adapted physical education and exercise, exercise physiology, and clinical rehabilitation.

Ermioni (Noni) Katartzi is an Associate Professor in Motor Development and Motor Coordination Difficulties at the Department of Physical Education and Sport Science at Serres, Faculty of Physical Education and Sport Sciences, Aristotle University of Thessaloniki, Greece. She holds a BSc in Physical Education and Sport Science from the Aristotle University of Thessaloniki, a MSc in Sport Science from the Faculty of Physical Education and Sport Science at Komotini, Democritus University of Thrace, Greece, an MA in Education from the Greek Open University, Patras, Greece, and a PhD in Human

Performance and Health, Faculty of Physical Education and Sport Sciences, Aristotle University of Thessaloniki, Greece. She has been an Internship Scientific/Academic Manager at the Department of Physical Education and Sport Science at Serres, since 2015/2016.Her research interests focus on issues regarding the assessment of motor abilities, skills and motor coordination difficulties in children/adolescents/young adults and the implementation of intervention programs aiming to promote participation in physical activity for children/adolescents/young adults with motor coordination difficulties. Her research studies have been published in high impact journals and she participated as a key note speaker in scientific congresses, seminars or social meetings. She is a reviewer in several international journals.

Eleni Fotiadou is a Professor in the Department of Physical Education and Sport Science at the Aristotle University of Thessaloniki, where she specializes in Adapted Physical Education. She is an integral part of the Laboratory of Motor Behavior and Adapted Physical Activity and she has a long teaching, research and professional experience associated to physical education for individuals with disabilities. Her research interests are primarily centered on adapted dance, exploring its physiological and psychological benefits, as well as its role in leisure activities, and her research studies have been published on high impact journals. Professor Fotiadou's commitment to inclusive physical education is evident through her extensive teaching and research contributions, making her a prominent figure in the field of Adapted Physical Education.

Giagazoglou Paraskevi is a Professor of special education in Aristotle University of Thessaloniki. She has a long teaching, research and professional experience associated to children’s development, evaluation of psychomotor abilities of children with and without disabilities and intervention programs. She has more than 100 papers published in international and Greek scientific journals as well as in proceedings of international and Greek conferences with over 1600 references to her work and h-index 20 based on her profile in the Google scholar database.