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[See table of contents](#)

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Article abstract

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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 \leq 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 \geq 16th percentile (Green Zone) do not have a motor impairment (Henderson et al., 2007). Clinically, a cut-off score of \leq 15th percentile to diagnose children with DCD is recommended, while a stricter cut-off score of \leq 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

Characteristic	Zones of motor difficulty			Statistical test *	p value	Effect Size
	No motor difficulties (Green Zone)	At risk (Amber Zone)	Definite motor difficulties (Red Zone)			
	($n = 228$)	($n = 37$)	($n = 37$)			
	Mean (Standard Deviation)					
Weight (kg)	19.49 (3.65)	20.37 (4.73)	19.36 (4.57)	$F_{(2,299)} = 0.88$	$p = 0.417$	$\eta^2 = 0.006$
Height (cm)	112.24 (6.29)	112.70 (6.28)	111.60 (6.37)	$F_{(2,299)} = 0.28$	$p = 0.751$	$\eta^2 = 0.002$
BMI (kg/m ²)	15.40 (2.09)	15.92 (2.71)	15.41 (2.60)	$F_{(2,299)} = 0.84$	$p = 0.432$	$\eta^2 = 0.006$
Age (months)	59.73 (6.73)	58.68 (6.61)	57.84 (6.63)	$F_{(2,299)} = 1.50$	$p = 0.225$	$\eta^2 = 0.010$

*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]
		<i>n</i> (%)		
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		<i>t</i> (<i>df</i>)*	<i>p</i> value	Effect Size	
	Mean (Standard Deviation)					
At risk (<i>n</i> = 37)	Male (<i>n</i> = 20)	Female (<i>n</i> = 17)				
	Dexterity	16.55 (5.26)	17.76 (4.53)	<i>t</i> (35) = -0.74	<i>p</i> = 0.462	<i>d</i> = 0.25
	Ball Skills	18.35 (3.64)	16.53 (2.48)	<i>t</i> (35) = 1.74	<i>p</i> = 0.090	<i>d</i> = 0.58
Balance	25.05 (4.85)	24.59 (5.15)	<i>t</i> (35) = 0.28	<i>p</i> = 0.781	<i>d</i> = 0.09	
Significant difficulties (<i>n</i> = 37)	Male (<i>n</i> = 22)	Female (<i>n</i> = 15)				
	Dexterity	13.36 (5.72)	13.33 (4.94)	<i>t</i> (35) = 0.01	<i>p</i> = 0.987	<i>d</i> = 0.01
	Ball Skills	14.55 (3.28)	14.60 (3.76)	<i>t</i> (35) = -0.47	<i>p</i> = 0.963	<i>d</i> = 0.01
Balance	18.27 (5.80)	18.67 (7.37)	<i>t</i> (35) = -0.18	<i>p</i> = 0.857	<i>d</i> = 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 *		<i>t</i> (<i>df</i>)**	<i>p</i> value	Effect Size	
	Mean (Standard Deviation)					
At risk (<i>n</i> = 37)	4 years (<i>n</i> = 18)	5 years (<i>n</i> = 18)				
	Dexterity	19.50 (4.47)	14.28 (3.59)	<i>t</i> (34) = 3.86	<i>p</i> < 0.001	<i>d</i> = 1.29
	Ball Skills	16.61 (3.53)	18.50 (2.81)	<i>t</i> (34) = -1.77	<i>p</i> = 0.085	<i>d</i> = 0.59
Balance	23.33 (3.86)	26.67 (5.33)	<i>t</i> (34) = -2.14	<i>p</i> = 0.039	<i>d</i> = 0.72	
Significant difficulties (<i>n</i> = 37)	4 years (<i>n</i> = 22)	5 years (<i>n</i> = 14)				
	Dexterity	13.18 (5.90)	13.36 (4.68)	<i>t</i> (34) = -0.09	<i>p</i> = 0.926	<i>d</i> = 0.03
	Ball Skills	13.95 (3.15)	15.64 (3.79)	<i>t</i> (34) = 1.45	<i>p</i> = 0.157	<i>d</i> = 0.48
Balance	18.00 (6.84)	19.21 (6.01)	<i>t</i> (34) = -0.54	<i>p</i> = 0.591	<i>d</i> = 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		<i>t</i> (<i>df</i>)*	<i>p</i> value	Effect Size	
	Mean (Standard Deviation)					
At risk (<i>n</i> = 37)	Normal Weight (<i>n</i> = 29)	Overweight/ Obese (<i>n</i> = 8)				
	Dexterity	16.76 (4.91)	18.38 (5.01)	<i>t</i> (35) = -0.82	<i>p</i> = 0.418	<i>d</i> = 0.33
	Ball Skills	18.28 (2.97)	14.75 (2.81)	<i>t</i> (35) = 2.99	<i>p</i> = 0.005	<i>d</i> = 1.22
Balance	24.62 (5.15)	25.63 (4.21)	<i>t</i> (35) = -0.50	<i>p</i> = 0.616	<i>d</i> = 0.21	
Significant difficulties (<i>n</i> = 37)	Normal Weight (<i>n</i> = 28)	Overweight/ Obese (<i>n</i> = 9)				
	Dexterity	13.82 (4.80)	11.89 (6.92)	<i>t</i> (35) = 0.94	<i>p</i> = 0.353	<i>d</i> = 0.32
	Ball Skills	14.64 (3.48)	14.33 (3.46)	<i>t</i> (35) = 0.23	<i>p</i> = 0.817	<i>d</i> = 0.09
Balance	18.82 (6.86)	17.22 (4.74)	<i>t</i> (35) = 0.65	<i>p</i> = 0.521	<i>d</i> = 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		<i>t</i> (<i>df</i>)*	<i>p</i> value	Effect Size
	Mean (Standard Deviation)				
At risk (<i>n</i> = 37)	Rural (<i>n</i> = 28)	Urban (<i>n</i> = 9)			
	Dexterity	16.61 (5.01) 18.67 (4.52)	<i>t</i> (35) = -1.10	<i>p</i> = 0.280	<i>d</i> = 0.43
	Ball Skills	17.64 (3.50) 17.11 (2.47)	<i>t</i> (35) = 0.42	<i>p</i> = 0.676	<i>d</i> = 0.17
Balance	25.25 (4.58) 23.56 (4.92)	<i>t</i> (35) = 0.89	<i>p</i> = 0.377	<i>d</i> = 0.32	
Significant difficulties (<i>n</i> = 37)	Rural (<i>n</i> = 34)	Urban (<i>n</i> = 3)			
	Dexterity	13.32 (5.56) 13.67 (2.08)	<i>t</i> (35) = -0.10	<i>p</i> = 0.917	<i>d</i> =0.08
	Ball Skills	14.50 (3.30) 15.33 (5.50)	<i>t</i> (35) = -0.39	<i>p</i> = 0.692	<i>d</i> =0.18
Balance	18.88 (6.26) 13.33 (6.66)	<i>t</i> (35) = 1.46	<i>p</i> = 0.152	<i>d</i> =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		<i>t</i> (<i>df</i>)*	<i>p</i> value	Effect Size
	Mean (Standard Deviation)				
At risk (<i>n</i> = 37)	Right (<i>n</i> = 30)	Left (<i>n</i> = 7)			
	Dexterity	17.23 (4.30) 16.57 (7.43)	<i>t</i> (35) = 0.32	<i>p</i> = 0.753	<i>d</i> = 0.11
	Ball Skills	17.70 (2.74) 16.71 (5.12)	<i>t</i> (35) = 0.72	<i>p</i> = 0.478	<i>d</i> = 0.24
Balance	24.13 (4.58) 27.86 (5.55)	<i>t</i> (35) = -1.86	<i>p</i> = 0.071	<i>d</i> = 0.73	
Significant difficulties (<i>n</i> = 37)	Right (<i>n</i> = 30)	Left (<i>n</i> = 7)			
	Dexterity	12.97 (5.13) 15.00 (6.35)	<i>t</i> (35)=-0.90	<i>p</i> = 0.373	<i>d</i> = 0.35
	Ball Skills	14.53 (3.63) 14.71 (2.63)	<i>t</i> (35)=-0.12	<i>p</i> = 0.902	<i>d</i> = 0.06
Balance	17.90 (6.26) 20.71 (6.92)	<i>t</i> (35)=-1.05	<i>p</i> = 0.300	<i>d</i> = 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

Motor Variables	Cohen's <i>d</i>				
	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% (Giagkazoglou 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 & Zurec, 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 & Zurec, 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., 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.

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