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Relation Between Percent Body Fat and Fundamental Motor Skills in Pre-School Children age 3-6 years

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A B S T R A C T

It is quite well known that excessive body fat in children is interpreted as a marker of inhibited physical activity and motor performance. This study aimed to establish whether severe impairment of fundamental motor skills (defined as performance under 5th centile of norms) will be significantly more frequently identified in pre-schoolers age 3-6 years with amount of body fat higher than 85th centile of norms. Research sample consisted of 496 (females=241, males=255) pre-schoolers selected from specific district of Prague, Czech Republic. The MABC-2 was used for the assesment fundamental motor skills. Equations for body fat estimation in children identified 35.8% children with body fat>85th centile of norms, 61.7% within 15th–85th centile, and 2.5% of children<15th centile of norms. Results revealed that children whose body fat was higher than 85th centile of norms or lower than 15th centile had double the frequency of severe motor problems. Interestingely on the other hand we found no signficant differences in the frequency of high above average performances>90th centile in MABC-2 between fat 8.4% and non fat children 10.7%. We suggest that amount of body fat is not a clear predictor for the degree of fundamental motor skills.

Key words: *fundamental motor skills, MABC-2,motor performance, pre-school chidren, adipose tissue, fat*

Introduction

Previous research proved that the decreased amount of physical activity (PA) is a cause of poor performance in motor abilities in childhood (Deforche et al., 2003; Wedderkopp, Froberg, Hansen & Andersen, 2004; Pařízková, Sedlak, Dvořáková, Lisá & Bláha, 2012). A significant negative correlation between obesity and less daily moderate physical activity and daily vigorous physical activity in pre-school and middle school child populations is also a well-known fact (Trost, Kerr, Ward & Pate, 2001; Davies, Gregory & White 1995; Salbe et al., 2002; Graf et al., 2004). On the other hand, much less attention has been paid–and especially in pre-school children–to examining whether over-weight and obese individuals have higher prevalence for severe motor difficulties in fundamental motor skills (FMS). FMS is described by fine and gross motor skills, coordination and balance manifestations. The degree of FMS has a direct impact on motor development of an individual and plays a crucial role in early child´s physical, cognitive and social development (Gallahue, Ozmun & Goodway, 2011; Cools, Martelaer, Samaey & Andries, 2009). Currently, a few studies suggested a potential relationship between preschoolers' level of FMS and the amount of PA (Butcher & Eaton, 1989; Saakslahti et al., 1999; Fisher et al., 2005). However, the revealed results have not provided a clear enough support to establish a clear link. In particular performance in FMS correlates low with the amount of PA. Moreover, results of study Cliff, Okely, Smith and McKeen (2009) showed that the relationship between FMS and PA may be conditioned in pre-shoolers by different variables including: gender, movement skill sub-domain or intensity of physical activity. Studies of the relation between body size measured by BMI and FMS performance show similar inconsistent results. Williams et al. (2008) revealed low non-significant correlations (from 0.03 to 0.13) in pre-schoolers between *z*-BMI and FMS measured by Motor Skill Protocol performance. Siahkouhian, Mahmoodi and Salehi (2011), examined the relation between BMI and the degree in FMS measured by Motor Skill Protocol at 7 to 8 year old children also concluded that „hypothesis of a perceptual-motor deficit in obese children is rather speculative and must therefore be addressed further". On the other hand, Okely, Booth and Chey (2004) found that results of six FMS (run, vertical jump, catch, overhand throw, forehand strike, and kick) are significantly related to BMI and waist circumference. In this research, normal weight middle age school children were two to four times more likely to be more advanced in FMS than overweight and obese children of both sexes. Differences in FMS performance with the emphasis on the performance in each FMS sub-domains were provided by Morano, Colella and Caroli (2011). They revealed that overweight and obese children showed the poorest performance in locomotor and object-control tasks. D'Hondt, Deforche, De and Lenoir (2009), who examined relationship between FMS assessed by Movement assessment battery for children (MABC-2) and BMI in 5 to 10 year olds, also discovered significant relation between FMS and body size. However, in their study only obese children scored significantly worse in FMS in comparison to their normal-weight and overweight peers. Logan, Scrabis-Fletcher, Modlesky and Getchell (2011) did not reveal any significant relation between BMI and MABC-2 r=-0.237 in pre-school children. However, these authors pointed that pre-school children classified as over-weight and obese might have lower FMS than their normal weight and underweight counterparts.

It is evident from aforementioned studies that previous research has been mainly focused solely on the absolute difference in FMS performances between normal-weight, overweight and obese children. Therefore, there is a lack of information whether children with high adipose tissue generally expressed

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more severe motor difficulties in FMS. Moreover, to date the majority of studies have used only one indicator for assessing of morphological composition of the BMI which has its definite limitations. Our hypothesis is that severe impairment of fundamental motor skills will be significantly more frequently identified in pre-schoolers aged 3-6 years with the amount of body fat higher than the 85th centile of norms.

Methods

Research sample

The research sample consisted of 496 (females=241, males=255) pre-schoolers aged 3 to 6.9 years ($\bar{x}$=4.75; ±1.21) selected from a specific district of Prague, the Czech Republic. Four kindergartens were selected randomly from a reference list of all general kindergartens (not private kindergartens) on the territory of Prague which do not have any specialization (e.g., sport, language). The research was approved by the Ethics Committee of the Faculty of Physical Education and Sport, Charles University, and the parents of all participants signed voluntary an informed consent. The data were anonymized.

Data collection

Anthropometry - all anthropometry markers were measured in the same time of the day from 2 pm to 4 pm by three trained research persons. All anthropometric measurements were done according to the reference manual Lohman, Roche and Martorell (1988) using standardized equipment. We measured:

Weight: medical calibrated weight type TPLZ1T46CLNDBI300 was used to assess weight to nearest 0.1 kg

Height: portable anthropometer P375. Measurements were taken to nearest 0.1 cm

Skinfolds: triceps and subscapular skinfolds were measured by Harpenden type caliper (skinfolder) with accuracy of 0.2 mm

Percentage of body fat (%BF): the amount of body fat was calculated according of equations Slaughter et al., (1988) using the data of skinfold measuremnst on triceps (SFT) and subscalpular (SFS)

For male with the sum of skinfolds less than 35 mm the following equation was used: $\%BF=1.21(SFT + SFSRr) – 0.008*(SFT + SFS)^2 – 1.7$

For female with the sum of skinfolds less than 35 mm the following equation was used: $\%BF=1.33*(SFT + SFS) – 0.013*(SFT + SFS)^2 – 2.5$

For male with the sum of skinfolds higher than 35 mm the following equation was used: $\%BF=0.783*(SFT + SFSr) + 1.6$

For female with the sum of skinfolds higher than 35 mm the following equation was used: $\%BF=0.546*(SFT + SFS) + 9.7$

(Slaughter et al., 1988)

Inter-rater reliability of measurement - Since skinfolds were measured by three examiners, firstly a pilot testing of measurement consistency on n=20 pre-schoolers from selected kindergartens was conducted.

Inter-rater reliabilities as intra-class correlation coefficients (ICC) of three examiners in skinfolds measurement were: ICC triceps=0.91; ICC subscapula=0.95; ICC suprailiaca=0.90; ICC calf=0.94.

The final classification of individuals into categories was done according norms (Schwandt, Eckerstein & Haas, 2012):

1) underfat<15th centile
2) proportionate fat 16th–85th centile
3) overfat>86th centile

Fundamental Motor Skills - The test of the Movement Assessment Test Battery for Children-2 (MABC-2) (Henderson, Sugden & Barnett, 2007) was used for assessing of the degree of FMS. In particular the age band (AB1) variant intended for children aged 3-6 years was used. Data collection from MABC-2 was carried out by three research trained teams. Each team contained five trained persons who measured FMS by MABC-2 in selected kindergartens in the same time of the day from 9 am to 11 am. Children were assessed individually.

According to Henderson et al. (2007), MABC-2 is a comprehensive diagnostic tool for evaluation of motor development and revealing of motor difficulties with different severity. MABC-2 AB1 included eight indicators divided into three domains.

1) dexterity – a) Post coins; b) Threading beads, c) Drawing trail
2) Aiming and Catching – a) Catching bean bag; b) Throwing bean bag onto mat
3) Balance – a) One-leg balance; b) Walking heels raised; c) Jumping on mats

According to the Examiner's manual (Henderson et al., 2007), all raw scores were converted to standard age-normed scores and further to a total test score (TTS PCT) In literature there are many solutions how to assess the degree of motor difficulties. In this study we adopted the recommendations of the following authors: Henderson et al. (2007); Schott, Alof, Hultsch and Meermann (2007). According to these recommendations, TTS PCT≤5th centile showed severe motor difficulties with high probability of developmental coordination disorder (DCD). TTS PCT≤15th of centile is considered as an indicator of risk of DCD.

Data analysis

Frequencies of MABC-2 TTS PCT (i)≤5th centile, (ii)≤15th centile and (iii)≥16th centile and their differences between 1) underfat children; 2) proportionate fat children and 3) overfat children were analysed by chi-square statistic: contingency tables and Fischer's exact test $p<0.05$ and effect size $ES>0.14$. The differences in total and standard scores from MABC-2 between proportionate fat children and overfat children were analysed by non-parametric Mann Whitney U test $p<0.05$ ES $r>0.30$ (Cohen, 1988). All statistical procedures were carried out in the NCSS2007 program (Version 2007; NCSS, Kaysville, UT, USA).

Results

Table 1 shows basic descriptive information about mean values of the selected research sample. Mean values of weight

Table 1. Personal height, weight and amount of body fat in pre-school children

Variables	3 years (n=118)	4 years (n=139)	5 years (n=121)	6 years (n=118)
Age M(SD)	3.5 (0.27)	4.41 (0.29)	5.41 (0.29)	6.5 (0.30)
Height in cm M(SD)	100.44 (4.89)	107.26 (5.25)	113.7 (4.92)	119.72 (6.01)
Weight in kg M(SD)	15.80 (2.19)	17.58 (2.26)	19.66 (2.86)	22.59 (3.15)
Subcutaneous fat in % M(SD)	15.39 (2.41)	15(2.49)	15.27(3.37)	15.46 (3.7)

Note: M – mean, SD – standard deviation

and height in each age category of measured pre-school children reflected the 49th up to 52th centile of Czech norms (Vignerová et al., 2006). However, average values of subcutaneous fat were in all age categories on the 75th centile of norms (Schwandt et al., 2012). This result confirmed a previously observed long term trend in increasing of adipose tissue even in pre-school children.

From the entire sample, 178 children (35.8%, 112 boys and 66 girls) were identified as having higher percentage of body fat than the 85th centile; 306 children (61.7%, 140 boys and 166 girls) had proportionate body fat and 12 children (2.5%, 6 boys and 6 girls) were identified as underfat with the percentage of body fat<15th of centile. Further it was revealed that overfat and underfat children have double the frequency of severe motor difficulties and risk of DCD in comparison to proportionate fat counterparts Chi-square=12.71, df=4, Effect size=0.16 (Table 2).

Table 2. Incidence of movement difficulties with regard to amount of adipose tissue

Proportion of children with and without motor difficulties	Under fat<15th centile (n=12)	Proportionate fat 15th–85th centile (n=306)	Overfat>86th centile (n=178)
Proportion of participants in each category in %	2.5	61.7	35.8
Proportion of children in risk of DCD MABC-2≤15th centile	3 (25%)**	38 (12.4%)	38 (21.4%)**
Proportion of children with severe motor difficulties MABC-2≤5th centile	2 (16.7%)**	17 (5.55%)	26 (14.6%)**
Proportion of children without motor difficulties MABC-2≥16th centile	9 (75%)	268 (87.6%)	140 (78.6%)

Note: ** significantly higher frequency of severe motor difficulties and risk of DCS $p<0.05$; Effect size >0.14

From this perspective it seems that the amount of adipose tissue plays a crucial role in FMS performance. Neverthless, we were interested to know whether the category of overfat children will have the average score in MABC-2 significantly worse in comparison to their peers. The analysis of differences in MABC-2 total score (TTS), standard scores (TSS), and highly above TTS PCT≥90th centile are provided solely for overfat children and their proportionate counterparts as the sample size of underfat children (n=12) does not have adequate power.

Table 3. Difference in Total test score (TTS), total standard score (TSS) and proportion of high above centile score (PCT)≥90th centile

	Under fat<15th centile (n= 12)	Proportionate fat 15th–85th centile (n=306)	Overfat>86th centile (n=178)
Mean (SD) TTS	71.18 (16.7)	77.97 (10.02)	74.9 (12.5)*
Mean (SD) TSS	8.45 (3.2)	10.64 (8.4)	9.1 (3.29)*
PCT (proportion in %)≥90th centile	0 (0%)	32 (10.4%)	15 (8.4%)

Note: * significantly higher score $p<0.05$ however with unsufficient Effect size $r<0.30$

Overall differences in the average TTS and TSS presented in tab 3 showed that overfat children scored significantly worse in MABC-2. However, these differences were identified as significant only in terms of statistical significance z-2.37 and z-2.58; $p<0.05$. The effect sizes of TTS and TSS respectively between overfat and proportionate fat children were low $r=0.11$. Moreover, the results surprisingly revealed that in children with significantly high above average score TTS PCT≥90th centile is not significantly less overfat in comparison to their counterparts (Table 3).

Discussion

Our hypothesis is that severe impairment of fundamental motor skills will be significantly more frequently identified in pre-schoolers aged 3-6 years with the amount of body fat higher than the 85th centile of norms. Results from MABC-2 revealed that children whose body fat was>85th centile of norms or<15th centile had double the frequency of severe motor difficulties TTS PCT≤5th centile in comparison to peers with body fat in the range between 15th–85th centile. The finding of a higher frequency of motor difficulties in overfat pre-school children is in agreement with finding of Okely et al. (2004). In their research over-weight and obese pre-school children aged four and six years had double the frequency of the lowest mark on artificially established 5 point FMS scale in comparison to their non-overweight peers. However, beside that our results interestingly showed that not only a high amount of adipose tissue but also a very low amount of tissue may represent a predisposition for poor FMS performance. Further, in conformity with previous studies (D'Hondt et al., 2009; Morano et al., 2011) we found that overfat pre-schoolers generally scored significantly worse in FMS performance in comparison to proportionate fat peers. However, in this research differences in the total score and standard score between proportionate fat children and overfat children significantly differ only statistically $p<0.05$. When the effect size (practical significance) was checked, no significant differences were revealed $r=0.11$ between the two groups. This finding is in contrast with the results from previous researches because the degree of difference in FMS performance between sub-samples classified according to the centile rank of BMI was much larger. For instance, the results in Logan et al. (2011) showed that children with BMI>85th centile had MABC-2 average centile score TTS PCT=38.7 and children with BMI in the range between 25th–85th centile TTS PCT=60.7. It means the difference was 22 centile points.

However, in our study the average centile difference of 5.7 centile points on the scale between overfat TTS PCT=42.28 and proportionate fat TTS PCT=47.98 was found. According to many authors (Scheffler, Ketelhut, & Mohasseb, 2007; Rietsch, Eccard, & Scheffler, 2013) value of BMI is constituted by others body compartments in comparison to itself estimated

amount of subcutaneous body fat. Therefore one of possible cause of this inconsistency in results could be obviously due to different information which provides BMI in comparison to estimated amount of subcutaneous body fat. Although it seemed that overfat pre-school children generally have a lower level of FMS in comparison to their proportionate fat peers, one finding from this study goes contrary to it. Surprisingly, overfat and proportion fat children had proportionally almost the same distribution of scores in FMS>90th centile of MABC scale. Therefore, it seems that the high amount of subcutaneous fat may not have such an evident decreasing effect for FMS performance. However, it must be mentioned that even in early childhood there is evidence that overfat children have faster tempo of biology maturation (Pařízková, 2010). Therefore without information about biology age of children we can't confirm if similarity in frequency of above average performance between proportionate and fat children is not caused mainly due to their biological maturation diversity. However, these results suggest that detailed investigations of FMS performance levels with equally distributed sample sizes of underfat, overfat or overweight and obese children is necessary to understand the importance of the amount of adipose tissue in the domain of FMS. We do realize the highly unequal representation of individuals in each sub-sample to be a definite source of limitations.

Children whose body fat was>85th centile of norms or<15th centile had double the frequency of severe motor difficulties TTS PCT≤5th centile in comparison to peers with body fat in the range between 16th–84th centile. Interestingly, these results showed that not only a high amount of adipose tissue but also a very low amount of fat tissue may represent a predisposition for poor FMS performance. On the other hand, overfat and proportion fat children had proportionally almost the same distribution of high above average scores in FMS>90th centile of MABC scale. Therefore, it seems that amount of body fat in pre-school children doesn't represent sufficient predictors of the level of fundamental motor skills. We suggest that greater emphasize should be put on research where connection between FMS, body composition, cognitive abilities and motor experiences in pre-schoolers would be assessed.

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