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Anthropometric Influence on Physical Fitness among Preschool Children: Gender-Specific Linear and Curvilinear Regression Models

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A B S T R A C T

There is evident lack of studies which investigated morphological influence on physical fitness (PF) among preschool children. The aim of this study was to (1) calculate and interpret linear and nonlinear relationships between simple anthropometric predictors and PF criteria among preschoolers of both genders, and (2) to find critical values of the anthropometric predictors which should be recognized as the breakpoint of the negative influence on the PF. The sample of subjects consisted of 413 preschoolers aged 4 to 6 (mean age, 5.08 years; 176 girls and 237 boys), from Rijeka, Croatia. The anthropometric variables included body height (BH), body weight (BW), sum of triceps and subscapular skinfold (SUMSF), and calculated BMI (BMI = BW (kg) / BH (m)^2). The PF was screened throughout testing of flexibility, repetitive strength, explosive strength, and agility. Linear and nonlinear (general quadratic model $y=a+bx+cx^2$) regressions were calculated and interpreted simultaneously. BH and BW are far better predictors of the physical fitness status than BMI and SUMSF. In all calculated regressions excluding flexibility criterion, linear and nonlinear prediction of the PF throughout BH and BW reached statistical significance, indicating influence of the advancement in maturity status on PF variables Differences between linear and nonlinear regressions are smaller in males than in females. There are some indices that the age of 4 to 6 years is a critical period in the prevention of obesity, mostly because the extensively studied and proven negative influence of overweight and adiposity on PF tests is not yet evident. In some cases we have found evident regression breakpoints (approximately 25 kg in boys), which should be interpreted as critical values of the anthropometric measures for the studied sample of subjects.

***Key words**: breakpoint, critical value, linear-nonlinear relationship, motor status*

Introduction

Defining the relationships between and within different anthropological dimensions is a problem often investigated within anthropological sciences[1]. In kinesiology (sport and exercise science), the focus is mostly on defining characteristic influence of the anthropometric dimensions on motor endurance and/or performance status[2]. In doing so, researchers use simple (univariate) or more complex (multivariate) statistical techniques and calculations. However, in most cases, linear regression and correlation models are calculated[1–2].

It is known that overweight and adiposity negatively influence the physical fitness (PF) in children. D'Hondt et al.[3] demonstrated that general motor skill level is lower in obese children than in normal weight and overweight peers. Fogelholm et al.[4] found that overweight had the most negative association with cardiorespiratory and muscle endurance, and explosive power tests but not with flexibility measures. The conclusions brought in other studies[5,6], are quite similar. In short, most investigators found somehow impaired PF and decreased motor performance in overweight and adipose children.

When discussing problem of the anthropometric influence on the PF status additionally, some specific issues should be noted. First, practically all of the studies

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that dealt with anthropometrics in relation to PF in preschoolers used linear models in defining the relationships between observed variables. It is particularly an important problem because previous investigations clearly noted that relationships between anthropometric indices and fitness status should be explained according to their true nature and not only statistically noted. For example, Huang and Malina in two studies[7–8] evaluated the relationship between body mass index (BMI) as an indicator of overweight and the four components of health-related PF in a nationally representative sample of Taiwanese youth 9–18 years of age and found a parabolic relationship in some cases. Their conclusion supports previous findings of Sekulic et al.[9] when they evidenced a nonlinear »logic of the relationship« between anthropometrics and motor-endurance status (i.e., PF) in adolescent males, and concluded that nonlinear relationships between anthropometric predictors and PF criteria can be expected when there is evident cause (for example, biomechanical and/or physiological cause) why two absolutely different subgroups of subjects should reach equal results on the criterion and if a nonlinear relationship can be explained following some evident nonlinear square basis. In both cases, the interpretation of the correlations exclusively on the linear basis would lead to serious interpretative errors.

Finally, there is evident lack of studies that dealt with the problem of anthropometric influence on PF among Croatian preschoolers.

Consequently, the aim of this study was to calculate and interpret linear and nonlinear relationships between simple anthropometric predictors and PF criteria among preschoolers of both genders. We were of the opinion that this approach will allow precise interpretation of the morphological influence on the PF status in preschool children. Additionally, we thought that our investigation will allow us to define some critical breakpoints of the anthropometric variables which should be considered as a certain »critical value« in prevention of the negative morphological influence on the PF status in preschool children.

Methods

Subjects

The sample of subjects consisted of 413 preschoolers aged 4 to 6 (mean age, 5.08 years; 176 girls and 237 boys) from Rijeka, Croatia. All subjects were healthy, with neither evident nor documented physical aberrations, and were involved in the preschool kindergarten program for at least one year prior to testing of this study.

Variables

The sample of anthropometric variables included body height (BH in cm), body weight (BW in kg), sum of triceps and subscapular skinfold (SUMSF in mm), and calculated BMI (BMI=BW (kg)/BH (m)^2). The BH was measured by a scale fixated on the wall, the BH by a digital scale, and skinfolds using a Lange caliper. All variables were recorded three times, and average result was used for further analysis.

Physical fitness was screened throughout testing of flexibility (sit and reach – S&R), repetitive strength (dynamic muscular endurance, sit-ups in one minute – SIT-UPS), explosive strength (standing long jump – LONG JUMP), and agility (shuttle run test – AGILITY). Flexibility (S&R): The device had a measuring scale where 0 cm was at the level of the feet. With shoes removed and knees fully extended, subjects were instructed to slowly reach forward as far as possible on the scale. The most distant point reached with the finger tips was recorded (nearest centimeter). The best of three trials was retained for analysis. Repetitive strength (dynamic muscular endurance, SIT-UPS): The subject was supine on a mat with knees bent at right angles and hands crossed on the chest. The examiner held the subject's ankles firmly for support and maintained the count. The subject's elbows had to touch the knee on the same side with each sit-up. After each sit-up, both scapulae returned to the mat, but the head did not have to touch it. The number of sit-ups completed in 15 seconds was recorded. Explosive strength (LONG JUMP): Standing at the starting line, the subject was instructed to take off with both feet and jump horizontally forward as far as possible. A preparatory crouch was permitted. The distance (nearest centimeter) from the starting line to the heel of the closest foot was recorded. The best of the three trials was retained for analysis. Agility (AGILITY): This test requires the person to run as fast as possible back and forth between two parallel lines that are 9 meters apart. Starting at the first line opposite the two sponges, upon the go signal, the participant runs to the other line, picks up a first sponge, and returns to place it behind the starting line, then returns to pick up the second sponge and runs with it back across the line. The best of the three trials was retained for analysis.

Testing design

The testing was arranged in small groups, and all subjects were tested by the same examiner. On the first day of anthropometrics, flexibility and repetitive strength were tested, and on the second day, the subjects were tested on explosive strength and agility. The rest between test trials was set on 30 seconds for explosive strength and 2–3 minutes for agility. Prior to study and the testing, at least one parent of the children was informed about the purpose and the aim of the investigation and gave the written consent for his/her child participation. The testing was done throughout September and October 2008.

Statistical analysis

For all multiple-item variables, we have calculated reliability parameters (Cronbach alpha and average-inter-item correlations). Differences between genders were established using the t-test for independent samples. Following descriptive statistical analysis, linear and second-

-order nonlinear regressions were calculated. In nonlinear calculation, squared function was used to determine the possible curvilinear relationships between predictors (anthropometric variables) and criteria (PF variables). The general equation for the square function was used: $y=a+bx+cx^2$.

Results

All reliability coefficients are high, ranging from 0.89 to 0.92 (for motor variables); and 0.97 (BW) to 0.98 (BH) for Cronbach alpha, and 0.77 to 0.89 for average inter-item correlation (from 0.77 to 0.82 for motor variables, 0.94 (BW) and 0.86 (BH). Because genders significantly differed in some variables (SUMSF, LONG JUMP, and S&R), linear and nonlinear regressions were calculated separately for boys and girls.

Evidently, BH and BW are far better predictors of the PF than BMI and SUMSF. Briefly, in all calculated regressions excluding flexibility criterion, linear and nonlinear prediction of the PF throughout BH and BW reached statistical significance.

Interestingly, none of the observed anthropometric predictors was found to be significantly correlated to flexibility status of children aged 4–6 years.

Generally, differences between linear and nonlinear regressions are smaller in males than in females. In other words, when calculated for boys, wherever nonlinear calculation was significant, the linear one explained somewhat smaller (but also significant) part of the criterion's variance. On the other hand, in girls some linear calculations were not significant while nonlinear correlation reached appropriate statistical level. In short, BMI is significantly related to agility performance when nonlinear regression was calculated, whereas the linear one did not

TABLE 1
DESCRIPTIVE STATISTICS (MEAN – X, STANDARD DEVIATION – SD) FOR BOYS AND GIRLS; T-TEST DIFFERENCES BETWEEN GENDERS

	Boys (N=236)	Girls (N=175)
	$\overline{X}$±SD	$\overline{X}$±SD
BH (cm)	114.92±7.24	114.12±7.17
BW (kg)	21.69±4.37	20.95±3.93
BMI (kg/m²)	16.29±1.90	16.00±1.94
SUMSF (mm)	10.17±4.38	11.93±5.07*
AGILITY (s)	16.13±2.56	16.50±2.14
LONG-JUMP (cm)	98.84±22.04	91.83±21.11*
SIT-UPS (rep)	9.51±5.39	10.22±4.92
S&R (cm)	4.74±6.04	7.02±7.00*

BH – body height; BW – body weight; BMI – body mass index; SUMSF – sum of the triceps and subscapular skinfold; AGILITY – agility test; LONG-JUMP – standing long jump; SIT-UPS – number of sit-ups performed in 15 seconds; S&R – sit and reach flexibility test; * denotes significant t-test differences

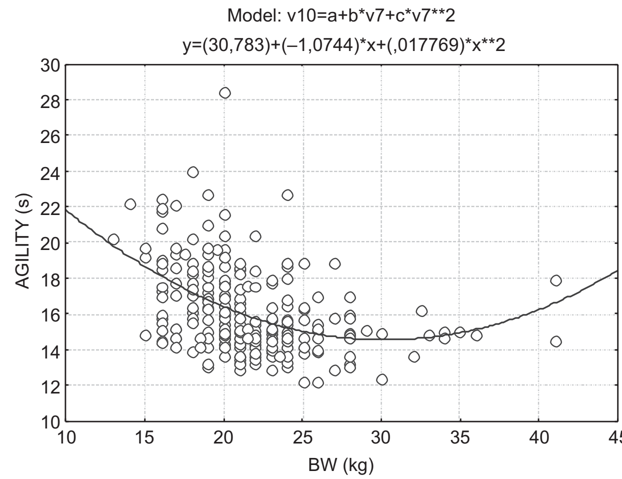

Fig. 1. Nonlinear regression between body weight (BW) agility (AGILITY) for boys.

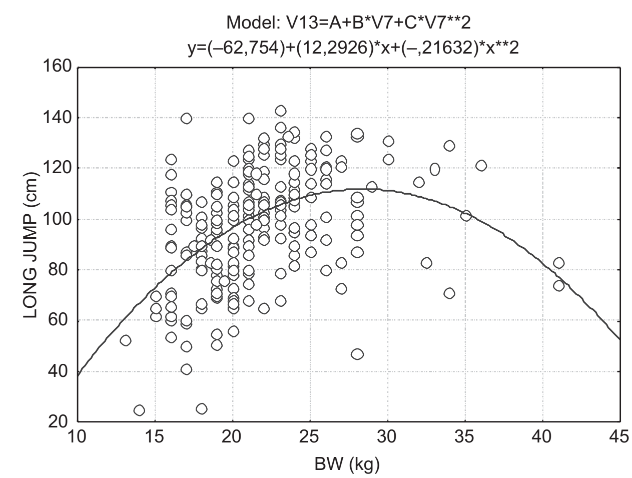

Fig. 2. Nonlinear regression between body weight (BW) explosive strength (LONG JUMP) for boys.

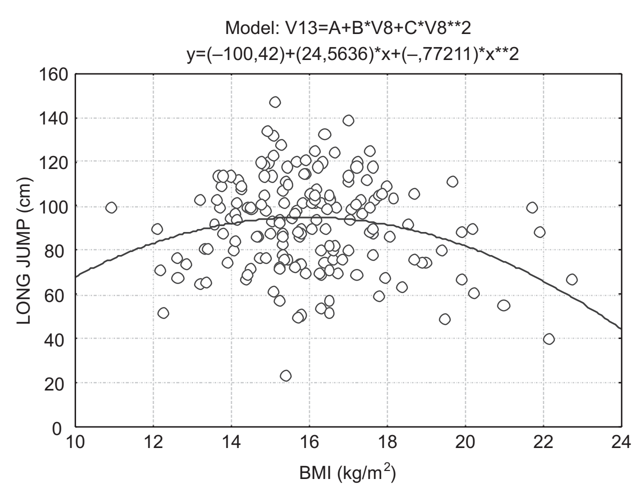

Fig. 3. Nonlinear regression between body mass index (BMI) explosive strength (LONG JUMP) for girls.

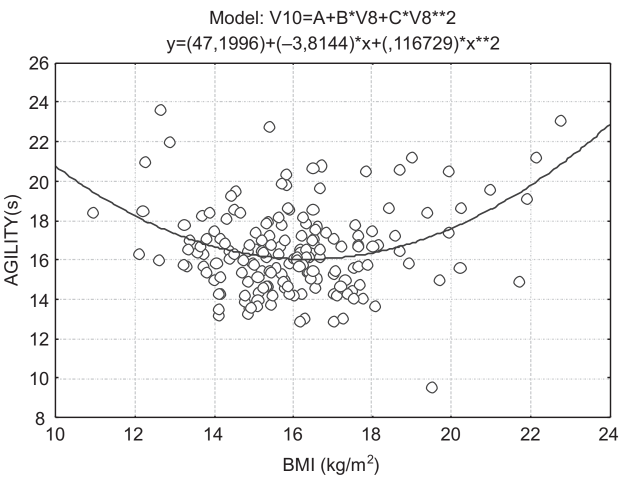

Fig. 4. Nonlinear regression between body mass index (BMI) agility (AGILITY) for girls.

reach statistical significance. Additionally, the same findings are evident for BMI → LONG JUMP, and BW → SIT-UP relationships (significant curvilinear and non-significant linear regressions) (Tables 1 and 2, Figures 1–4).

Discussion

Although results presented previously would allow us to broadly discuss the findings, in the following discussion, we will put emphasis on some issues we have judged as particularly important because of the study aims.

Anthropometric influence on the physical fitness among preschoolers

It is not rare that studies found BH as the most significant predictor of different PF and motor performance variables (see Malina et al 2004 for more details)[10] However, another issue deserves our attention. Exclusively of the study where authors investigated excellent young athletes on their characteristic sport achievement[11]; in investigations when authors sampled nonathletes and observed PF, and not specifically sport achievement, authors explained a smaller percentage of the PF variance throughout anthropometric predictors, than we have found in our study. Some important information can be drawn from these results. First, it seems that morphological features in general evidently more significantly influence the motor performance in younger than in older children (note that we have found no study which reported more than 21% of the common variance when correlated anthropometrics and PF in school age children and adolescents). It is most probably related to the fact that younger children (e.g., preschoolers) did not have time to develop PF and motor capacities independently of those morphological characteristics that directly influence certain motor performance. Second, although earlier investigations identified body fat (as a ballast mass) as the most important predictor of PF and motor status in childre[3,5], among preschoolers the BH and accompanied BW should be considered as the most significant predictors of the PF status. The later reason led us to conclude that the age we have included in our study (4–6 years) is probably a critical period in the prevention of obesity because negative influence of the body fat on motor manifestations is still not so evident (note that the SUMSF is not found as a significant predictor in any of the calculated regressions). Therefore, there are all indices that the preschool period should be observed as the critical timing in prevention of the obesity. In short, negative influence of the overweight on the PF is not jet evident and therefore, any kind of the intervention throughout the physical exercising should be considered as potentially highly effective.

Linear vs. nonlinear regressions in boys

Differences between linear and nonlinear models among boys are minor in comparison to the model differences among girls. However, some cases deserve attention. Most particularly, we will focus on BW → AGILITY (Figure 1) and BW → LONG JUMP (Figure 2) relationships where nonlinear regressions explained near twice of the common variance than the linear models. Influence of the anthropometric features on PF and motor status is regularly studied in children, but limited number of papers dealt with preschoolers[5]. Therefore, in explanation of the relationships we have previously mentioned, we will discuss the general growth and developmental dynamics in preschool age, as well as findings of the correlations between anthropometric and PF and motor status in somewhat older subjects. Evidently, nonlinear model significantly explains influence of the BW on the LONG JUMP and AGILITY. Such coincidence is not surprising, mainly because agility is known to be related to explosive strength, which is already noted.[12] However, the question which arises is why BW should be considered as an evident nonlinear predictor of the explosive strength (LONG JUMP) and agility in preschoolers? The power qualities of the muscular system are the origin both for agility and explosive strength because of a physiological basis[13]. As a result, we can offer possible explanation of the nonlinear character of the BW influence on these two motor abilities (e.g., agility and explosive strength). Evidently (see Figure 1), an increase of the BW up to approximately 25 kg significantly positively influences the LONG JUMP in boys. From the breakpoint (i.e., 25 kg), regression curve drastically changes direction, indicating the negative influence of the additional increase of BW on explosive strength (and related agility) parameters. The power and strength qualities in childhood increase as a function of growth[10] and accompanied increase of BH and also, to some extent, increase of BW. »Some extent« in this particular case means that BW increases linearly following an increase in BH. Almost certainly, in this particular age, this point should be approximated to 25 kg of BW for boys. From that breakpoint, regression curve considerably changes direction, indicat-

TABLE 2
LINEAR AND NONLINEAR REGRESSION MODELS BETWEEN ANTHROPOMETRIC PREDICTORS AND PHYSICAL FITNESS CRITERIA AMONG BOYS (A – COEFFICIENT OF THE INTERCEPTION; B – LINEAR REGRESSION COEFFICIENT; C – NONLINEAR REGRESSION COEFFICIENT; R – MULTIPLE CORRELATION; RSQ – COEFFICIENT OF THE DETERMINATION)

Criterion	Predictors	Model	R	RSQ	A	B	C
AGILITY (s)	BH (cm)	Linear	0.45*	0.20	33.82*	–0.15*	
		Nonlinear	0.47*	0.22	99.79*	–1.29*	0.00*
	BW (kg)	Linear	0.35*	0.12	20.53*	–0.20*	
		Nonlinear	0.43*	0.19	30.78*	–1.07*	0.01*
	BMI (kg/m²)	Linear	0.14*	0.02	19.23*	–0.18*	
		Nonlinear	0.15	0.02	24.00*	–0.74	0.01
	SUMSF (mm)	Linear	0.02	0.00	16.30*	–0.01	
		Nonlinear	0.02	0.00	16.28*	–0.00	–0.00
LONG-JUMP (cm)	BH (cm)	Linear	0.51*	0.26	–85.65*	1.57*	
		Nonlinear	0.55*	0.30	–890.00*	15.58*	–0.06*
	BW (kg)	Linear	0.33*	0.10	61.79*	1.66*	
		Nonlinear	0.47*	0.22	–62.75*	12.29*	–0.21*
	BMI (kg/m²)	Linear	0.04	0.00	89.97*	0.49	
		Nonlinear	0.10	0.01	–7.98	11.95	–0.32
	SUMSF (mm)	Linear	0.12*	0.01	104.61*	–0.64*	
		Nonlinear	0.13	0.01	109.97*	–1.57	0.03
SIT-UPS (rep)	BH (cm)	Linear	0.43*	0.18	–27.45*	0.32*	
		Nonlinear	0.45*	0.20	–158.08*	2.58*	–0.01*
	BW (kg)	Linear	0.36*	0.13	–0.21	0.44*	
		Nonlinear	0.41*	0.17	–18.56*	2.01*	–0.03*
	BMI (kg/m²)	Linear	0.16*	0.02	1.99	0.46*	
		Nonlinear	0.18	0.03	–17.97	2.79	–0.06
	SUMSF (mm)	Linear	0.02	0.00	9.13*	0.03	
		Nonlinear	0.12	0.01	12.22*	–0.49	0.01
S&R(cm)	BH (cm)	Linear	0.06	0.00	–1.81	0.05	
		Nonlinear	0.06	0.00	11.30	–0.17	0.00
	BW (kg)	Linear	0.06	0.00	2.73	0.09	
		Nonlinear	0.08	0.00	–2.13	0.50	–0.00
	BMI (kg/m²)	Linear	0.04	0.00	2.33	0.14	
		Nonlinear	0.05	0.00	–7.17	1.25	–0.03
	SUMSF (mm)	Linear	0.03	0.00	5.28*	–0.05	
		Nonlinear	0.04	0.00	5.77*	–0.13	0.00

BH – body height; BW – body weight; BMI – body mass index; SUMSF – sum of the triceps and subscapular skinfold; AGILITY – agility test; LONG-JUMP – standing long jump; SIT-UPS – number of sit-ups performed in 15 seconds; S&R – sit and reach flexibility test; * denotes significant coefficients

ing negative influence of each additional increase of the BW on explosive strength (LONG JUMP). Almost equal breakpoint can be seen on Figure 2, where we have presented the BW → AGILITY relationship. The relatively small difference between linear and nonlinear regression model for the BH → LONG JUMP (AGILITY) relationship additionally support all the findings previously discussed. In short, and as specified before, in this age, a BH increase is an indicator of growth and development[10]. Therefore, each increase of the BH is an indicator of the advance in maturity status and consequent improvement in muscular power capacities.

Linear vs. nonlinear regressions in girls

In girls, the BMI nonlinearly significantly explains explosive strength and agility achievement (Figures 3 and 4), whereas the calculation of the linear regression

TABLE 3
LINEAR AND NONLINEAR REGRESSION MODELS BETWEEN ANTHROPOMETRIC PREDICTORS AND PHYSICAL FITNESS CRITERIA AMONG GIRLS (A – COEFFICIENT OF THE INTERCEPTION; B – LINEAR REGRESSION COEFFICIENT; C – NONLINEAR REGRESSION COEFFICIENT; R – MULTIPLE CORRELATION; RSQ – COEFFICIENT OF THE DETERMINATION)

Criterion	Predictors	Model	R	RSQ	A	B	C
AGILITY (s)	BH (cm)	Linear	0.50*	0.25	33.75*	–0.15*	
		Nonlinear	0.51	0.26	85.80*	–1.06*	0.00
	BW (kg)	Linear	0.29*	0.08	19.85*	–0.16*	
		Nonlinear	0.39*	0.15	31.31*	–1.20*	0.02*
	BMI (kg/m^2)	Linear	0.07	0.00	15.12*	0.08	
		Nonlinear	0.35*	0.12	47.20*	–3.81*	0.12*
	SUMSF (mm)	Linear	0.00	0.00	16.46*	0.00	
		Nonlinear	0.10	0.01	17.54*	–0.16	0.00
LONG-JUMP (cm)	BH (cm)	Linear	0.44*	0.19	–56.03*	1.29*	
		Nonlinear	0.45	0.20	–497.87	9.05	–0.03
	BW (kg)	Linear	0.22*	0.05	66.73*	1.20*	
		Nonlinear	0.30*	0.09	–18.65	9.01*	–0.17*
	BMI (kg/m^2)	Linear	0.11	0.01	111.71*	–1.23	
		Nonlinear	0.25*	0.06	–100.42	24.56*	–0.77*
	SUMSF (mm)	Linear	0.05	0.00	94.72*	0.24	
		Nonlinear	0.06	0.00	93.19*	0.00	0.00
SIT-UPS (rep)	BH (cm)	Linear	0.24*	0.06	–9.05	0.16*	
		Nonlinear	0.30*	0.09	–186.82*	3.28*	–0.01*
	BW (kg)	Linear	0.11	0.01	7.21*	0.14	
		Nonlinear	0.26*	0.07	–16.09*	2.27*	–0.04*
	BMI (kg/m^2)	Linear	0.06	0.00	12.83*	–0.16	
		Nonlinear	0.14	0.02	–14.82	3.19	–0.10
	SUMSF (mm)	Linear	0.02	0.00	10.47*	–0.02	
		Nonlinear	0.02	0.00	10.18*	0.02	–0.00
S&R (cm)	BH (cm)	Linear	0.05	0.00	1.17	0.05	
		Nonlinear	0.07	0.00	–76.56	1.41	–0.00
	BW (kg)	Linear	0.05	0.00	4.87	0.10	
		Nonlinear	0.06	0.00	–0.24	0.56	–0.01
	BMI (kg/m^2)	Linear	0.02	0.00	5.37	0.10	
		Nonlinear	0.08	0.00	–19.44	3.11	–0.09
	SUMSF (mm)	Linear	0.00	0.00	7.04*	–0.00	
		Nonlinear	0.13	0.01	11.69*	–0.72	0.02

BH – body height; BW – body weight; BMI – body mass index; SUMSF – sum of the triceps and subscapular skinfold; AGILITY – agility test; LONG-JUMP – standing long jump; SIT-UPS – number of sit-ups performed in 15 seconds; S&R – sit and reach flexibility test; * denotes significant coefficients

did not reach statistical significance. Such difference in statistical significance of the linear and nonlinear regressions is rare to be found, although some studies offered explanations for such incidences. For example, in the study that basically aimed for the actualization of the nonlinear regressions[14], the authors stated that »significant nonlinearity and nonsignificant linearity« should be expected when two absolutely different groups of subjects (according to their results achieved on predictor variables; positioned marginally left and marginally right on the regression scatterplot) perform similarly on criterion. If simplified, it will lead us to the conclusion that, in our study, underweight girls (left side of the scatterplot) will achieve equal results as their overweight peers (right side of the scatterplott). However, in this particular case, we will not agree with such explanation. In short, and as discussed previously for boys, BH and BW are clearly intercorrelated in this age (e.g., in our study, the intercorrelation was 0.80 and 0.75 for boys and girls, respectively). The »left side« of the scatterplott does not therefore relate to »undernourished« and underweight girls but better to shorter ones, unadvanced in growth and maturity, and consequently, inferior in muscular capacities, which are physiologically the main prerequisites for the successful achievement in most of the motor manifestations we have studied herein (see previous text for more details and references). The significant nonlinear relationship between BMI and PF indices (agility and explosive strength) additionally supports our considerations (Table 3). Mathematically, the BMI is an index linearly dependent on the BW and nonlinearly dependent on BH (BMI = $BW(kg)/BH(m)^2$). Consequently, each change of the BW linearly influences the index, and each change of the BH has an impact on the BMI on a square basis. As a result, BW changes do not influence the changes in BMI as much as the BH changes (we must note that in our case, it would be more correct if we use the term »difference« instead of »change«, but we believe that it would make the complicated discussion even more difficult). One could argue that it is known that overweight children tend to be tall[7], but this confounding effect is, to the best of our knowledge, noted only in prepubescent and pubescent children and should not therefore be an issue in our study.

Conclusions

Based on the results presented and discussed so far, the following conclusions can be drawn:

In preschoolers, the BH and accompanied BW should be considered as most significant predictors of the PF.

Nonlinear regression models allowed us to define true nature of the anthropometric influence on the PF variables. More precisely, in some cases, the correlation coefficient, which was calculated throughout nonlinear models, was significant, whereas the linear correlation model did not reach statistical significance.

There are indices that the age of 4 to 6 years is probably a critical period in the prevention of obesity, mostly because the known negative influence of the body fat on PF tests is still not as evident as previous studies suggested for older children. Although we are aware that our considerations are somewhat pioneering and not sufficiently explored, the facts that we have used both linear and nonlinear regression models in defining anthropometrics → PF relationships (and therefore diminished the possibility that the »true logic« of the correlation is not evidenced) and randomly sampled subjects with relatively broad range of BMI (and consequently evidenced potential confounding influence of the anthropometric »outliers«), we are convinced that considerations previously brought out should be judged as correct to some extent.

In the following studies it would be important to develop the multiple regression linear-nonlinear models in defining the relationships between anthropometrics and motor status among the preschool children. In short, linear multivariate regression models regularly explains the greater percentage of the univariate regression models. Therefore, the equal trend could be expected in curvilinear regressions.

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UTJECAJ ANTROPOMETRIJSKIH MJERA NA FIZIČKI FITNES KOD PREDŠKOLACA: SPOLNO SPECIFIČNI LINEARNI I NELINEARNI REGRESIJSKI MODELI

S A Ž E T A K

Malo je studija koje su se bavile povezanostima morfoloških antropometrijskih varijabli i mjera fizičkog fitnesa (FF) kod predškolske djece. Cilj ovog rada bio je (1) izračunati i interpretirati linearne i nelinearne zavisnosti između jednostavnih antropometrijskih prediktora i FF kriterija kod predškolaca oba spola, i (2) pronaći kritične vrijednosti antropometrijskih prediktora koji bi se mogli prepoznati kao regresijska prijelomnica i početak negativnog utjecaja prediktora na FF. Uzorak ispitanika sačinjavalo je 413 predškolaca od 4 do 6 godina (prosječna dob 5.08 godina; 176 djevojčica i 237 dječaka) iz Rijeke, Hrvatska. Antropometrijske varijable uključivale su tjelesnu visinu (TV), tjelesnu težinu (TT); zbroj kožnih nabora na tricepsu i leđima (SUMKN), i izračunati indeks tjelesne mase (BMI=TT(kg)/TV $(m)^2$). Mjere FF analizirane su kroz fleksibilnost, repetitivnu snagu, eksplozivnu snagu i agilnost. Linearni i nelinearni (generalni kvadratni model $y=a+bx+cx^2$) izračunavani su i interpretirani su paralelno. TV i TT su bolji prediktori FF nego BMI i SUMKN. U svim izračunatim regresijama osim predikcije fleksibilnosti, linearni i nelinearni modeli bili su statistički značajni, što ukazuje na izravan utjecaj stupnja rasta i razvoja na FF. Razlike linearnih i nelinearnih modela manje su kod dječaka nego kod djevojčica. Postoje neke naznake da je ovaj period života kritična dob za prevenciju od pretilosti. Naime, izrazito negativni utjecaj prekomjerne tjelesne težine i adipoziteta na FF, a koji je redovito dokazan kod starije djece, ovdje još nije izražen. U nekim slučajevima utvrđene su prijelomnice regresijske krivulje (aproksimativno 25 kg u dječaka), a koje se mogu interpretirati kao kritična vrijednost antropometrijskih mjera u analiziranom uzorku ispitanika.