ANTHROPOMETRIC AND MOTOR DETERMINANTS OF ENDURANCE RUNNING IN PRE-ADOLESCENT AGE

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Abstract
In this research, author endeavours to determine the extent of speed endurance (criterion) prediction, according to some anthropometric and motor variables (predictor). 174 male and female students (N=174), who are fourth grade of primary school in Valjevo, have been examined. Morphological characteristics have been examined using 14 standard anthropometric measures and motor ability with 6 battery tests, while speed endurance has been checked with the 3 minute running test. Multiple hierarchy analysis has been used for the statistical data processing. On the significance level (p<.05), achieved results show that predictor variables set among boys, with medium multiple correlation of R=.59, explains 21% of the criterion variability. Maximal positive direction of univariant statistically significant variable's correlation has following standardized non-zero regression variable coefficients: standing long jump, torso lifting and torso bending, while body mass has negative contribution to the criterion (β = -38, p < .01). Girl's multiple correlation coefficient has medium intensity (R=.53) and shows that predictor determinants evaluate criterion variance with the 19% on the level of statistical significance, which is less than 5%. The highest positive predictive value with the test for the functional abilities evaluation has following motor variables: tapping with a hand, standing long jump and chin ups endurance; while Beta coefficient of backward polygon predictor (β= -33, p< .03) has significant negative impact on aerobic endurance. Achieved results of multivariate regression model indicate to the fact that applied predictor sets of anthropometric and motor variables in pre-adolescent population, can reliably serve as a base for further longitudinal researches of anthropological fields. In this work is also debated about theoretical and practical implications of achieved findings.

Key words*: morphological characteristics, motor abilities, aerobic endurance, students*

Introduction

The basic imperative in physical education teaching is integral progress of total anthropologic student's status. Above mentioned aim could be achieved with the help of meticulous identification of complex relations and degree correlation set of anthropometric characteristics and motor-functional student's abilities. Organism speed endurance considers whole body ability to release energy for muscular contraction in relatively longer time period along with the big muscular groups work and to maintain physical activity of moderate intensity, without reduction of its efficiency. This ability of energy regulation and creation from glucose and free fatty acids is considered to be one of the most important components in functional domain, for it maintains physiological state of systems, which are important for total health organism condition. Manifest anthropometric measures present system of morphological constitution as a relatively constant whole of correlative body characteristics, formed from endogenous and exogenous factors. Motor abilities, achieved by training processes, or without them, are the most commonly determined as development degree indicators of mobile latent dimensions, which generate successful motion accomplishment. Theoretical phenomenon of speed endurance has been researched by many authors on the Yugoslavian territory. Forerunner of the speed endurance problem was Neljak's and collaborators research (2003), who determined mutual correlation between predictor variables system (6 motor abilities) and criterion aerobic endurance variable (6 minutes running) on the sample of 611 elementary school students. In his study, Mikulić (2009) analyzed training endurance possibility of children and young sportsmen, being in pre-adolescent, adolescent and post-adolescent period, according to biological organism limitations. Pucek and collaborators (2009) analyzed parameters for aerobic and anaerobic sportsmen capacity evaluation in two disciplines, football and athletics runners. Sekulić et al. results (2009) showed that boy's accelerated speed endurance development phase could be expected in the period of 11. to 15. year, while secondary school girl's sensitive phase period for aerobic endurance development is hardly recognizable. According to the Advanced 20 meters sprint test for maximal oxygen consumption prediction Stanković et al. (2008) examined effects of transformation procedure in the fitness abilities domain. Results have showed high-quality progress and improvement of (aerobic) functional examinees abilities. Applying the multiple hierarchy regression analysis, Ivanović and Mijić (2009) in their work determined statistically significant and positive multiple correlation shapes, of relatively high intensity between sets of motor-functional (aerobic) abilities variables and running (1000 meter) results of 102 cadet footballers. According to these authors researches, dominant univariate contribution of results prognosis in the middle distance running have examinees who have greater explosive strength.

On the sample of 195 boys, being 11-12 years old, Radovanović et al. (2009) executed experimental anthropometric measurements and functional testing. Achieved results showed that examinees of experimental group (active water polo players) have bigger body height, body mass and skinfold thickness, than students who just attended regular physical education at school. Pejčić et al. (2010) in their research determined that system of predictor (anthropometric and motor) variables applied on that the 4th grade students of primary school, has statistically significant influence on criterion variable (speed endurance). Maximal influences on *3 minute running*, among boys, *have: body mass, standing long jump, torso lifting and torso bending* variables, while among girls the greatest influence have *tapping with a hand, standing long jump, backwards polygon and chin ups endurance* variables. Also, according to these authors' researches, it is determined that, among both genders, motor abilities, which are formed on united base, participate in speed running endurance manifestation, while explosive legs running strength presents prevailing motor ability. Results in aerobic running endurance usually achieve boys on the base of *explosive and repetitive strength*, while girls achieve it according to the *movement frequency, body movement coordination and strength endurance*. Pejčić et al. (2010) in their research determined that aerobic capacity of pre-school boys and girls is influenced by morphological characteristics and motor abilities. Apart from that, individually and statistically significant increased influence values of morphological variables are: *body height, hand length, upper arm volume* and decreased values of boy's *upper arm skinfold* and girl's *leg length*. Ivanović and Ivanović (2010), on the sample of 7th and 8th primary school students established statistically significant correlation of functional abilities (maximal oxygen consumption, pulse frequency and vital lungs capacity) and 4 athletic disciplines (high jump, long jump, shot put and 60 meters starting block sprint). Having inspected before mentioned works, it is consequential that basic research problems can be reduced to the following questions: "Is there a linear correlation between anthropometric characteristics and motor abilities with speed endurance" and "How does the relation structure between them look like?". According to that approach, the main aim of the research is to determine intensity and relation direction (which is statistically different than zero) between some predictors- anthropometric marks and motor abilities- and criterion variable- speed endurance of pre-puberty, both male and female examinees. It is expected that achieved results of this transversal research, with a great probability, can serve as an authoritative base for understanding and more successful research of correlative, morphological and motor, most important mechanisms, which determine speed endurance in the pre-puberty period. Furthermore, it is assumed that newly achieved information enable new gaining of theoretical knowledge, which can contribute to the formation of as rational procedure as possible for diagnosis, optimal programming, monitoring development of researched anthropologic abilities and structuring of the most suitable teaching content technology for 12 years old (± 6 months) students.

Methods

Examinees sample

On the appropriate sample of 174 students (85 school boys and 89 school girls), 4. grade of primary school "Vladika Nikolaj Velimirović" from Valjevo (AS=12,54 decimal years; SD= 1,07), standard battery made from 11 anthropometric, motor and functional variables has been applied. Anthropometric measurements and motor examinees testing lasted, on average, for one school class. Data for research has been gathered in April of 2010. During anthropometric measurements and motor testing, all students were clinically healthy and all of them regularly attended physical education classes.

Variables

Set of 4 standard anthropometric measures (predictor variable): *longitudinal skeleton dimensionality*: body height-ATV, *body volume and body mass*: forearm volume- AOP; body mass-ATM, *subcutaneous fat tissue*: upper arm skinfold-ANN, has been used for morphological *characteristics* level evaluation. Anthropometric characteristics have been evaluated using the International Biological Program- IBP (Lohman, Roche & Martorell, 1988). According to Metikoš et al. (1982) method*, motor abilities* or primary 1. rank factors level evaluation has been executed, using the following batteries of 6 standard motor composite tests (predictor variables): *flexibility*: torso bending-MPR, *frequency movement speed*: taping with a hand- MTR, *body movement coordination*: backward polygon- MPN, *explosive lower limbs strength*: standing long jump-MSD, *repetitive strength*: torso lifting: MTP and *shoulder and upper limbs static power:* chin ups endurance-MIV. 3 minute running test-F3 (criterion variable) has been used for functional abilities evaluation (aerobic endurance).

Research technique and procedure

Body height has been measured in millimeters, according to Martin's measuring method, where barefoot examinee has been in upright position, with the head in "Frankfurt's plane", relaxed arms beside the body, heels close to each other and with divergent bare feet on solid, horizontal ground. Result has been read with 0, 1 centimeter precision. Body mass has been measured with leveled, medical and digital weight scale, which has been positioned on horizontal ground. Result has been read with 0, 1 kg precision. Forearm volume has been measured with centimeter division plastic tape, which is put around the forearm, 10-15 centimeters below the facial disjointed shoulder bump, directly to its centre line and its upper third (it is measured in 2-3 places). Result has been read with 0,1 centimeter precision.

Skinfold thickness of upper arm has been measured with caliper, according to John Bull's method, on the middle upper arm's back side, while standard pressure of caliper jaw on the skin has been 10 g/ mm². Values have been read two seconds after the caliper has been put on the skinfold. Static anthropometric measuring protocol (examinee body is motionless) has been conducted by the same examiner, at the same time of a day (morning hours), with the same anthropological instruments and the same technique. In that manner, the possibility of a mistake, which is manifested in measuring with higher number of controls, is reduced to minimum. During the anthropometric measuring, barefoot examinees have been in the gym equipment and in standard position. All measures have been taken on standard anthropometric points, on the left side of symmetric parts by a controller. All the measuring instruments have been calibrated before the beginning of measuring. Measuring has been done 3 times, in order to avoid any mistake, and then data's arithmetic mean has been calculated. Measuring results have been read while the instrument has still been on the examinee. Special anthropologic paper has been created for each examinee. Before any measuring, anthropologic points have been marked on each examinee. All measuring instruments have been calibrated before the measuring. Measuring results have been read while an instrument has still been on a examinee. Applied sample of motor tests has been executed repeatedly in morning hours for 3 times, with short breaks, according the standardized measuring procedure in school's physical education hall by the same measure man. Before testing, measure man has, once or twice demonstrated, the task for each examinees group. During the testing, and with the air temperature of 18-24º C, order of motor tests realization has been as following: *torso bending, taping with a hand, backward polygon, and standing long jump, torso lifting and chin-ups endurance*. Testing has been conducted according to the station rules, in circular work formation, which consisted of 10 examinees maximally, in gym equipment, at the same time.

Results and discussion

Achieved results have been statistically processed, table presented and textually interpreted. Inspecting the table 1, in which descriptive, statistic measuring subject of *student's* anthropometric characteristics and motor abilities variables are presented, it is obvious that discriminability of most variables is at a satisfactory level. However, since the skewness values are increased- asymmetry (Sk)- and kurtosis – curviness (Ku), with insignificant positive asymmetry, the differentiation of two variables compared to theoretical distribution is present: backward polygon and chin-ups endurance. Achieved matrix data cells information about distribution differentiation of analyzed variables in motor space, stresses the fact that most examinees have achieved better results in factor of *shoulder and upper limbs static strength* or that aforementioned motor tasks have been adequate and easy, while in factor of *whole body movement coordination* achieve worse results. In terms of descriptive statistical aspect it means that this motor test has been "difficult" to perform for the sample of pre-puberty period examinees.

Table 1 - Descriptive statistic variable-school boys

Variable	AS	MIN.	MAX.	±SD	SK	KU
ATV - mm	139.10	124	162	6.20	0.39	0.02
ATT - kg	36.08	19	66	7.49	0.71	0.83
AOP - mm	18.10	14	29	1.95	0.92	1.25
ANN - mm	12.01	3	27	4.18	0.73	0.09
MTR - att.	24.17	13	37	3.48	-0.20	0.57
MSD - cm	129.20	81	182	19.10	0.09	-0.40
MPN - sec	19.02	9.8	50	6.93	1.64	3.79
MPT - att.	29.05	3	47	6.33	-0.70	1.12
MPR - cm	46.94	15	71	10.00	-0.10	-0.40
MIV - cm	19.25	0	111	17.00	1.88	5.51
F3 - min	524.10	181	786	80.00	-0.70	2.09

3 minutes running test- F3 (criterion variable) has been used for *functional abilities (aerobic endurance)* evaluation. On the significance level ($p<.05$), in the table 2, multiple correlation coefficient value, which is ($R=.59$), can be seen. That indicates to the fact that moderate correlation between predictor variables and criterion variable exists. Mutual variability of 21% can be considered as satisfactory predictive value.

Table 2 - Multiple regression analysis - boys

Variable	B	T	P
ATV - mm	0.09	0.81	0.39
ATT - kg	-0.38	-3.01	**0.01**
AOP - mm	0.04	0.00	0.77
ANN - mm	-0.03	-0.19	0.79
MTR - att.	-0.02	-0.25	0.76
MSD - cm	0.29	2.36	**0.02**
MPN - sec	-0.06	-0.12	0.32
MPT - att.	0.64	5.43	**0.05**
MPR - cm	0.20	1.98	**0.02**
MIV - cm	0.05	0.67	0.51

$R= .59$ $R^2= .21$ $F=3.09$ $Q< .05$*

By partial monitoring of boy's non-zero standardized partial regression coefficient values, (table 2) statistically significant positive influence of 4 predictor variables (*body mass, standing long jump, torso lifting and torso bending*) to criterion variable (*3 minutes running*) can be established. On the other hand, regression plane has shown that speed endurance depends on decreasing value of body mass variable.

Inspecting the table 3 containing school girls' descriptive statistic variable of anthropometric characteristics and motor abilities, the satisfactory sensitivity of the most measuring subjects is obvious.

Table 3 - Descriptive statistic variable - school girls

Variable	AS	MIN.	MAX.	±SD	SK	KU
ATV	132.14	101	163	13.05	-1.14	0.37
ATT	45.95	19	130	30.02	1.72	1.23
AOP	47.02	15	114	38.94	0.69	-1.39
ANN	10.22	3	34	4.57	1.12	1.68
MTR	23.02	12	38	3.88	0.29	0.04
MSD	132.04	69	179	20.07	-0.21	-0.19
MPN	129.00	9	256	70.91	-0.29	-0.92
MPT	29.06	1	48	8.01	-0.79	1.30
MPR	49.02	24	79	10.03	-0.04	-0.61
MIV	19.31	0	109	16.96	-2.01	5.37
F3	508.01	161	759	86.98	-0.41	0.81

Anthropometric variables: body mass and upper arm skinfold, have positive numeric values of skewness asymmetry (Sk), while body height has negative direction, with insignificant asymmetry. Achieved indicators of applied variables distribution distinction indicate to the fact that most of the female examinees have less morphological latent dimensions (*body mass and subcutaneous fat tissue*), but greater morphological latent dimension (*longitudinal skeleton dimensionality*). We should pay attention that *chin ups endurance* variable has positive direction, which indicates to the fact that female examinees results are piled up in the zone of weaker values of *arms and shoulders static strength factors*. Therefore, this motor task is inadequate and "difficult" to perform. Basic results of girls' multiple regression are given in the table 4. On the significance level .05, and by data matrix consideration, the moderate linear correlation between predictor anthropometric and motor variables with criterion variable is detected, while coefficient multiple correlation value is (R-.53), which from the regression aspect explains 19 % of mutual criterion variability.

Table 4 - Multiple regression analysis - girls

Variable	B	T	P
ATV	0.02	0.56	0.56
ATT	-0.06	-1.44	0.14
AOP	-0.05	-1.31	0.18
ANN	0.00	-0.02	0.98
MTR	0.44	3.41	**0.01**
MSD	0.61	4.55	**0.05**
MPN	0.33	-3.28	**0.03**
MPT	0.05	1.31	0.18
MPR	0.02	0.7	0.47
MIV	0.55	4.47	**0.02**

$R = .53 \quad R^2 = .19 \quad F = 3.41 \quad Q < .05^*$

Using the univariant numeric characteristics analysis of predictor and criterion tested set variables in matrix cell data, it can be determined that none anthropometric variable is not significantly bigger than (static) zero. So, none of them is relative in explanation of relations between motor abilities and 3 minutes running test. Therefore, on one side boys at this age in speed endurance can endure their values thanks to their total motor abilities values, and on the other hand, non-zero values of standardized partial regression motor coefficients variables (β): *taping with a hand, standing long jump, backwards polygon and chin-ups endurance*, have maximal and statically significant positive contribution in applied functional abilities test explanation. In the end of linear correlations view, which are statistically different from zero, it can be established that boys' set of anthropometric and motor variables is much better predictor of speed endurance criterion (R=.59) than girls' (R=.53). Furthermore, findings of both male and female pre-puberty examinees and being exposed in the regression plane, stress the fact that anthropometric characteristics set is not statistically and mutually correlated with organisms speed endurance. Apart from that, it is determined that boy's greater body mass negatively affects to results of 3 minutes running functional testing. Using further univariant analysis, it is determined that predictor examinees set of 3 analyzed motor variables (*standing long jump, torso lifting and torso bending*) have *statistically significant impact on criterion variable*. On the other hand, results in aerobic capacity have been achieved by examinees, who primarily used basic motor factors of (leg's) *explosive strength*, (stomach muscles') *repetitive strength* and (hamstring thigh muscles') *flexibility*. On the achieved results findings of multiple hierarchy regression analysis it can be established that girls' motor space the statistically significant univariant tests (*taping with a hand, standing long jump, backward polygon and chin-ups endurance*) impact on aerobic endurance, is determined; so speed *frequency, explosive strength of lower limbs, whole body movement coordination and shoulder and upper limbs static strength* are dominant factors of organism's speed endurance. In the end of these achieved results view and according to expectations, it can be concluded that achieved findings in this work are in accordance with earlier research results (Pejčić et al., 2009).

Conclusion

According to the achieved results of multiple hierarchy regression analysis, in the conducted quantitative research, the general conclusion is gained (with minimal error probability): applied predictor models of anthropometric and motor variables in pre-puberty period population, have statistically significant and moderate correlation with criterion speed endurance variable with mutual variability of 21% (boys) and 19% (girls). With regression aspect it stresses the fact that functional ability (speed endurance) is in relative amount defined with examinees' anthropometric characteristic and motor abilities. Non zero standardized partial regression coefficient (β) outcome of both male and female examinees, showed that in speed endurance latent dimension manifestation united motor abilities participate, while univariant legs' explosive strength in running presents central motor boys' and girl's ability. Furthermore, it is established that dominant results of functional abilities evaluation are achieved by

boys due to significant partial predictors of explosive and repetitive strength factors, while girls' speed endurance, taking into consideration that they have optimal anthropometric characteristics, is generated by factors of speed, movement frequency, explosive strength of lower limbs, coordination body movement and static strength of shoulder and upper limbs. According to determined dominant factors of lower limbs explosive strength and torso repetitive strength, movement frequency and body movement coordination, significant advancement of optimal speed endurance prediction of 4th grade primary school students can be achieved. One of the basic limitations of findings generalization is the fact that the research has been done on the relatively insufficient sample of examinees and variables. Therefore, in order to achieve more certain conclusions, apart from transversal, further longitudinal design researches of pre-puberty students' complex model anthropometric and motor speed endurance determinates, with involvement of grater variables and examinees number, are needed.

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ANTROPOMETRIJSKE I MOTORIČKE DETERMINANTE IZDRŽLJIVOSTI TRČANJA U PREADOLESCENTNOM UZRASTU

Sažetak

U ovom istraživanju autori su nastojali utvrditi granice izdržljivosti (kriterij) u skladu s morfološkim i motoričkim varijablama (prediktori). Ukupno 174 ispitanika muškog i ženskog spola, učenika četvrtih razreda osnovne škola u Valjevu je ispitano. Morfološke značajke ispitane su korištenjem 14 standardnih mjera, a motoričke s baterijom od 6 testova, dok je izdržljivost provjerena testom trčanja 3 minute. Multipla hijerarhijska analiza je provedena za statističku obradu podataka. Na razini značajnosti p<0.05), dobiveni rezultati su pokazali da prediktorski skup kod dječaka, uz osrednju multiplu korelaciju (R=0.59) objašnjava 21% varijabiliteta kriterija. Pozitivno su orijentirani slijedeći prediktori: skok u dalj s mjesta, podizanje trupa, dok je masa tijela imala negativan doprinos objašnjenju kriterija (β = -38, p < 0.01). Multipla korelacija kod djevojčica bila je umjerenog intenziteta (R=0.53) i pokazala je da prediktori objašnjavaju 19% varijabiliteta kriterija na statističkoj razini manjoj od 5%. Najveću pozitivnu prediktivnu vrijednost za procjenu funkcionalnog kriterija imale su varijable: taping rukom, skok u dalj s mjesta i izdržaj u visu, dok je Beta koeficijent poligona natraške bio negativan (β= -33, p< .03) i ima negativan utjecaj na aerobnu izdržljivost. Dobiveni rezultati multivarijantne regresijske analize pokazuju činjenicu da primjenjeni prediktorski skupovi sastavljeni od morfoloških i motoričkih varijabli u preadolescentnom uzrastu mogu pouzdano poslužiti kao temelj za buduća longitudinalna istraživanja u antropološkom području. U ovom radu također je raspravljeno o teorijskim i praktičnim imlikacijama dobivenih rezultata.

Ključne riječi: *morfološke značajke, motoričke sposobnosti, aerobna izdržljivost, učenici*

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