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Original scientific paper

Relation between Anthropometric Characteristics and Kinematic Parameters which Influence Standing Long Jump Efficiency in Boys and Adolescents

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A B S T R A C T

The aim of this research was to determine the relation between the anthropometrical variables and kinematic parameters that influence the standing long jump efficiency in boys and adolescents aged 4 to 18, as well as students of second year of Faculty of Kinesiology. With this aim, a sample of 120 examinees has been selected and divided into 5 experimental groups consisting of 20 boys and adolescents (aged 4 to 6, 7 to 9, 10 to 12, 13 to 15, 16 to 18), and one control group consisting of 20 second year students of Faculty of Kinesiology. The sample of variables consisted of 21 kinematic parameters relevant for efficient standing long jump performance, followed by battery of 13 morphological characteristics, as well as the age of the examinees. This research determined the relation between certain morphological characteristics and kinematic parameters relevant for standing long jump performance. It can be concluded that in adults, the jump length was primarily influenced by body mass, subcutaneous fat tissue and body fat percentage, while in younger age groups, besides the mentioned measures, the examinees who were taller, had longer arms and legs achieved better results.

Key words: *standing long jump, kinematic parameter, morphological variables, boys, adolescents*

Introduction

Since the mid-twentieth century, when[1] determined the development changes in standing long jump performance, the test was used in studying basic motor patterns[2,3]. Today, the standing long jump test performance is used in evaluation of explosive power of the jumping type in children, students, athletes and grown-ups, with the aim of evaluating the state of the individual, that is, control of training of teaching process, and help with planning and programming the work[4–6]. Many scientists used the biomechanical methods (kinematic analyses, kinetic, electromyographic and isokinetic measuring) so as to explain the configuration and optimum body segments coordination during the performance of standing long jump motor task. However, there are only a few researches done on younger population, especially pre-school children, in which it was determined that the fundamental motor stereotype of the mentioned movement has not been developed enough[7–9]. The fact is, if the standing long jump test was applied with the purpose of reviewing motor abilities, this movement had to be technically clear and acquired in a proper was so as to give the desired results, on which further scientific cognitions and adequate measuring conclusions could be made.

Further on, the standing long jump test, besides being a complex movement demanding a high level of motor knowledge and coordination abilities, is very influenced by the growth, development and maturation[10,11.] Also, among other, the researchers refer to the unsatisfactory metric characteristics of standing long jump test[12,13], as a measuring instrument used to collect data regarding motor status of children. The main part of »guilt« in not achieving the expected and desired results lies on the problematic of the measuring, meaning, the conditions, surroundings and time, during the measuring[14], measuring protocol (kinesiometric conditions), that is, familiarisation[15], children motivation[16]. With the aim of analyzing the standing long jump test, the movement is observed through four basic phases, which influence the length of the jump, from the scientific point of view: preparation phase, take off phase, flight phase and landing phase.

As a result of conducted kinematic analysis in researches by[17,18], the insight into the internal structure of movement is possible, and it can be determined that the standing long jump performance demands a highly coordinated movement of certain body segments during the

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preparation phase, take off phase, flight phase and landing phase, influencing the total length of the jump.

Therefore, the problem of this research was to study the takeoff preparation, the moment of take off, flight and landing during the standing long jump as key phases in performing a successful jump. The results of kinematic analysis of relevant parameters describing body geometry during standing long jump, speed of body segments and center of mass, as well as temporal and spatial parameters of jump, would offer the possible answer to the question of the existence of general technical pattern that the jumpers would use in their jumps. Also, based on the detailed kinematic analysis of the key phases of standing long jump movement structure, it will be obtained the movement model performed by selected athletes, which will be used in determining the influence of morphological characteristics on the jump length in younger age groups.

Until today, the movement structure of standing long jump performance was the subject of many scientific researches. The basic aim of these studies was to research the different aspects of standing long jump so as to understand the factors that influence the jump control and quality better, as well as optimization of body segments movement during the performance of the mentioned activity with significant amount of explosive power of jump type. The obtained cognitions were published in numerous papers[19,20]. The basic aim of this research was to determine the relation between the anthropometrical variables and kinematic parameters that influence the standing long jump efficiency in boys and adolescents aged 4 to 18, as well as students of second year of Faculty of Kinesiology.

Methods

Sample of examinees

Based on the cognitions of previous researches, and in concordance with the aim of this research, the sample of 120 male examinees was selected and divided into five experimental groups, each consisting of 20 entities for every individual age group of boys and adolescents aged 4 to 18, and one control group made of 20 students of second year of Faculty of Kinesiology. In this way, the representative sample of boys of younger, middle and older pre-school age was included, while the group of second year students of Faculty of Kinesiology in Zagreb represented the model of measured movement structure performance.

Sample of variables

The sample of variables consisted of 21 kinematic parameters, important in defining the model, that is, relevant for the efficient standing long jump performance[9,17,21,22]. All the variables were described and analyzed through 4 basic jump phases (1. Preparation phase, 2. Take off phase, 3. Flight phase, 4. Landing phase), referring to body geometry, body segments and center of mass speed during swing, take off, flight and landing, and temporal and spatial jump parameters (Tables 1, 2, 3 and 4).

Further on, in evaluating the morphological status of examinees, the following battery of 13 anthropometrical measures was applied:

- Longitudinal skeleton dimensionality – body height, arm length, leg length;
- Transversal skeleton dimensionality – fist diameter, ankle diameter, bi-cristal span;

TABLE 1
KINEMATIC PARAMETERS DETERMINING PREPARATION PHASE OF STANDING LONG JUMP

No.	Variable name	Mark	Unit of measurement
Body geometry in preparation phase of standing long jump			
1.	Shoulder angle at the beginning of preparation phase	SABPP	°
2.	Shoulder angle at the lowest point of centre of mass	SALPCM	°
3.	Hip angle at the lowest point of centre of mass	HALPCM	°
4.	Knee angle at the lowest point of centre of mass	KALPCM	°
Segments and center of mass speed in preparation phase of standing long jump			
5.	Time of achieving top shoulder speed before take off	TMAXSS	s
6.	Time of achieving top hip speed before take off	TMAXSH	s
7.	Time of achieving top knee speed before take off	TMAXSK	s
8.	Time of achieving top ankle speed before take off	TMAXSA	s

TABLE 2
KINEMATIC PARAMETERS DETERMINING THE TAKE OFF PHASE OF STANDING LONG JUMP

No.	Name of variable	Mark	Unit of measurement
Body geometry in takeoff phase of standing long jump			
1.	Elbow angle at take off	EATO	°
2.	Shoulder angle at take off	SATO	°
3.	Hip angle at take off	HATO	°
4.	Knee angle at take off	KATO	°
5.	Take off angle	TOA	°
Segments and center of mass speed in takeoff phase of standing long jump			
6.	Vertical velocity at take-off	VVTO	cm/s
7.	Horizontal velocity at take-off	HVTO	cm/s
Temporal and spatial parameters of standing long jump			
8.	Take off phase duration	TOPD	s

TABLE 3
KINEMATIC PARAMETERS DETERMINING THE FLIGHT PHASE OF STANDING LONG JUMP

No.	Variable name	Mark	Unit of measurement
Body geometry in flight phase of standing long jump			
1.	Elbow angle at the highest point of centre of mass	EAHPCM	°
2.	Shoulder angle at the highest point of centre of mass	SAHPCM	°
Temporal and spatial parameters of standing long jump			
3.	Flight phase duration	FPD	s

TABLE 4
KINEMATIC PARAMETERS DETERMINING THE LANDING PHASE OF STANDING LONG JUMP

No.	Variable name	Mark	Unit of measurement
Body geometry in landing phase of standing long jump			
1.	Landing angle	LA	°
Temporal and spatial parameters of standing long jump			
2.	Length of jump	LJ	cm

- Circular skeleton dimensionality – body mass, forearm circumference, lower leg circumference;
- Subcutaneous fat tissue – back skin fold, forearm skin fold, suprapatellar skin fold;
- Percentage of body fat in total body mass.

Also, the variables included:

- Age of the examinee.

Measuring protocol

All the anthropometrical measuring was conducted according to standard procedures and instruments, as described in International Biological Program (IBP).

The collection of kinematic variables was conducted with the help of two digital cameras, operating at speed of 60 images per second. Out of each examinee´s three recorded jumps, the longest jump was analyzed. The collected video records were digitalized and processed by standardized Ariel Performance Analysis System procedure[23].

Data processing methods

Statistica for Windows version 9 software was used in the analysis of collected data. The following central and dispersive parameters were calculated for all variables in all measuring: arithmetic mean (AM) and standard deviation (SD). The variables distribution normality was tested by Kolmogorov-Smirnov test. The influence of certain kinematic parameters on the standing long jump performance efficiency was determined by the gradual multiple regression analysis (forward and backward stepwise models). The relation between the anthropometrical variables with the kinematic parameters that influence the standing long jump efficiency was determined by the Pearson correlation coefficient.

Results

Descriptive statistics

At the very beginning of the study, result normality distribution was determined in all the measured variables, using the Kolmogorov-Smirnov test. The results of this test showed normal distribution of all variables, meaning that the empirical distributions in all measured variables did not significantly deviate from theoretical normal distribution (Tables 5 and 6).

Determining the kinematic parameters relevant in efficient standing long jump performance

In concordance with the problem of this research, determining the kinematic parameters relevant in efficient standing long jump performance in boys and adolescents aged 4 to 18 and second year students of Faculty of Kinesiology, the gradual multiple regression analysis was applied, by using two methods: forward and backward stepwise models.

Based on the obtained results of gradual multiple regression analysis of the group of second year students of Faculty of Kinesiology, who also represent a standing long jump model for the rest of the examinees, the existence of the statistically significant influence of certain kinematic parameters on the standing long jump performance efficiency was obvious (Tables 7 and 8). The results of gradual multiple regression analysis obtained by the method of gradual widening of kinematic parameters model showed that the horizontal velocity at take-off and the variables defining the work, or, swing of the arms during standing long jump performance – elbow angle at takeoff, shoulder angle at highest point of center of mass and shoulder angle at the beginning of preparation phase statistically significantly influenced the jump length (Table 7). The results of gradual multiple regression analysis obtained by the method of gradual narrowing of kinematic parameters model for the group of young athletes described the standing long jump performance model in even greater detail, that is, they gave even more precise specification of kinematic parameters relevant in efficient performance of the observed movement structure. Namely, the obtained results presented in Table 8 indicate that the standing long jump test was determined, besides the horizontal velocity at take-off and the variables that are the representative indicator of arm swing during the jump (elbow angle at moment of takeoff), also by the takeoff angle kinematic parameter.

TABLE 5
CENTRAL AND DISPERSIVE PARAMETERS OF MORPHOLOGICAL CHARACTERISTICS OF BOYS AND ADOLESCENTS AGED 4 TO 18 AND SECOND YEAR STUDENTS OF FACULTY OF KINESIOLOGY

Age	4–6 y		7–9 y		10–12 y		13–15 y		16–18 y		FK	
Morphological characteristics	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
Body height – LDBH	115.15	4.52	134.99	8.10	150.35	7.83	170.31	8.50	180.02	7.03	182.99	6.40
Arm length – LDAL	49.54	2.45	54.87	4.26	62.51	3.94	72.26	5.07	77.91	3.33	78.78	3.84
Leg length – LDLL	61.21	4.14	76.00	5.10	86.20	5.07	98.69	4.83	103.44	4.62	102.30	4.82
Fist diameter – TDFD	41.35	2.01	55.40	5.13	60.35	6.03	67.75	6.41	72.10	4.08	72.65	2.46
Ankle diameter – TDAD	55.70	2.13	62.70	4.51	67.03	4.58	70.60	3.76	72.40	4.33	74.75	2.34
Bi-cristal span – TDBR	15.74	1.28	19.06	2.42	20.86	1.98	25.78	3.17	30.43	1.80	30.68	1.49
Body mass – CDBM	21.25	2.66	34.15	8.99	42.98	11.15	64.06	14.18	73.02	15.89	82.43	7.72
Forearm circumference – CDFC	17.69	1.21	24.62	4.73	26.35	4.67	30.10	5.36	27.80	4.17	32.56	3.06
Lower leg circumference – CDLLC	24.04	1.85	31.39	4.34	34.85	4.84	38.47	4.78	36.84	3.94	38.52	2.46
Back skin fold – BSF	5.40	1.46	10.63	8.26	8.95	5.39	12.82	6.15	10.75	4.18	11.98	2.54
Upper arm skin fold – UASF	8.85	2.79	12.87	5.91	12.57	6.09	13.33	7.55	10.07	4.22	7.72	3.38
Suprapatellar skin fold – SPSF	9.93	3.14	11.98	3.79	11.10	5.61	11.45	5.61	9.02	4.33	7.57	2.03
Body fat percentage – BFP%	17.23	4.90	23.43	9.19	22.81	7.74	25.78	8.68	23.65	5.91	23.83	6.54

Legend: $\overline{X}$ – arithmetic mean, SD – standard deviation, FK – Faculty of Kinesiology students

The relationship between anthropometrical variables and kinematic parameters

The correlation analysis was conducted with the aim of determining the relation between anthropometrical variables and kinematic parameters influencing the standing long jump efficiency in boys and adolescents aged 4 to 18 and students of Faculty of Kinesiology. Based on the obtained Pearson correlation coefficients for the group of students of Faculty of Kinesiology, a conclusion can be made: there is a statistically significant relation between certain anthropometrical variables and kinematic parameters. To be precise, the highest negative relation was found between the body height, arm length, leg length, ankle diameter, bi-cristal diameter, body mass and lower leg circumference anthropometrical variables and the parameters defining arm work during standing long jump: shoulder angle at the beginning of preparation phase, shoulder angle at the lowest point of center of mass, shoulder angle in takeoff, elbow angle at the highest point of center of mass. It means that shorter examinees, with somewhat shorter arms and legs, narrower hips and ankles and lower leg circumference, had higher amplitudes in shoulder angle. Regarding the hip and knee angles in all jump phases, there was no significant relation except for the negative correlation in hip angle in the lowest point of center of mass with the lower leg circumference parameter. The indicators of top speeds were significantly negatively related to the bi-cristal diameter indicator, meaning that the examinees with lower bi-cristal diameter achieved higher speed. The takeoff angle kinematic parameter was significantly negatively correlated with the upper arm skin fold and body fat percentage. The same relation was found in the vertical velocity at take-off, take off phase duration and flight phase duration, while in the horizontal velocity at take-off variable there was no statistically significant relation to the morphological characteristics. The same relation was found in jump length parameter, with no statistically significant correlation to the anthropometrical variables.

However, the highest negative correlations of jump length parameter were obtained between the skin folds and body fat percentage variable, meaning that one of the most important limiting circumstances for students of Faculty of Kinesiology, which limits the jump length, was subcutaneous fat tissue, or the body mass of the jumper. This means that that the examinees that are more obese had shorter standing long jump length and were less efficient.

The obtained results of the Pearson correlation coefficients between morphological characteristics and kinematic parameters for the group of boys aged 4 to 6 indicate that there was a statistically significant relation between certain anthropometrical variables and kinematic parameters, which are important for efficient standing long jump performance. The highest positive relation was obtained between the subpatellar skin fold and parameters defining knee work during preparation phase and standing long jump take off phase (knee angle at the lowest point of center of mass and knee angle at takeoff). It means that the examinees with higher amount of subcutaneous fat tissue measured at lower leg did not squat deep enough at the moment of lowest center of mass at the preparation phase of long jump, and had higher values of knee angle. Further on, statistically significant correlations of elbow diameter and ankle diameter and the parameters defining arms work during jump were obtained, as well as high negative correlations of back skin fold, upper arm skin fold

TABLE 6
CENTRAL AND DISPERSIVE PARAMETERS OF KINEMATIC PARAMETERS OF BOYS AND ADOLESCENTS AGED 4 TO 18 AND SECOND YEAR STUDENTS OF FACULTY OF KINESIOLOGY

Age	4–6 y	7–9 y	10–12 y	13–15 y	16–18 y	FK
Kinematic parameters	$\overline{X}$ SD	$\overline{X}$ SD	$\overline{X}$ SD	$\overline{X}$ SD	$\overline{X}$ SD	$\overline{X}$ SD
Shoulder angle at the beginning of preparation phase – SABPP	55.39 38.74	20.50 68.79	32.34 70.06	50.46 47.44	46.17 46.05	63.34 16.07
Shoulder angle at the lowest point of center of mass – SALPCM	40.32 30.12	40.91 35.47	36.46 23.23	38.62 15.89	31.12 14.84	27.42 10.85
Hip angle at the lowest point of center of mass – HALPCM	61.14 18.86	82.73 19.36	76.03 16.18	78.09 17.02	89.25 15.40	85.35 15.09
Knee angle at the lowest point of center of mass – KALPCM	96.84 14.74	108.13 25.90	101.72 8.62	108.82 10.14	106.33 9.81	108.74 10.57
Elbow angle at takeoff – EATO	119.23 41.27	114.35 35.10	101.48 29.54	92.77 31.10	96.23 33.45	126.15 24.73
Shoulder angle at takeoff – SATO	91.38 73.52	91.17 68.57	124.35 30.27	115.10 31.86	115.76 38.43	152.43 13.51
Hip angle at takeoff – HATO	165.95 10.45	168.78 13.81	170.44 7.97	169.59 10.04	173.35 14.32	179.69 8.36
Knee angle at takeoff – KATO	147.22 9.52	145.58 14.53	144.33 10.52	146.33 8.96	147.52 11.88	159.60 8.52
Elbow angle at highest point of center of mass – EAHPCM	135.03 39.07	125.47 34.66	113.61 37.46	101.62 31.15	115.03 29.94	132.46 20.89
Shoulder angle at highest point of center of mass – SAHPCM	149.81 116.70	173.72 122.84	184.21 91.17	149.80 140.32	124.51 124.05	120.33 22.01
Take off angle – TOA	31.46 7.71	31.36 6.39	31.42 5.91	31.39 4.91	32.77 4.12	28.39 2.99
Landing angle – LA	42.57 6.31	40.40 5.23	39.18 3.07	38.21 4.32	36.56 3.91	36.72 2.91
Vertical velocity at take-off – VVTO	102.81 24.55	106.28 21.04	132.22 24.65	139.67 22.43	159.25 23.76	165.02 17.28
Horizontal velocity at take-off – HVTO	168.89 20.04	176.55 30.89	216.49 21.98	229.15 22.59	247.10 22.82	305.73 22.05
Time of achieving top shoulder speed before takeoff – TMAXSS	–0.23 0.16	–0.17 0.11	–0.20 0.10	–0.21 0.07	–0.16 0.09	–0.14 0.04
Time of achieving top hip speed before takeoff – TMAXHS	–0.07 0.02	–0.09 0.07	–0.05 0.02	–0.05 0.02	–0.03 0.02	–0.02 0.02
Time of achieving top knee speed before takeoff – TMAXKS	–0.06 0.02	–0.06 0.07	–0.05 0.02	–0.05 0.02	–0.04 0.02	–0.04 0.01
Time of achieving top ankle speed before takeoff – TMAXAS	–0.03 0.02	–0.03 0.02	–0.03 0.03	–0.03 0.02	–0.03 0.03	–0.08 0.04
Take off phase duration – TOPD	0.29 0.09	0.27 0.06	0.26 0.04	0.26 0.04	0.23 0.04	0.24 0.04
Flight phase duration – FPD	0.24 0.06	0.23 0.05	0.27 0.05	0.27 0.04	0.32 0.06	0.32 0.05
Jump length – JL	91.42 14.60	107.00 22.64	147.83 16.29	162.75 18.77	186.42 17.13	239.08 16.41

Legend: $\overline{X}$ – arithmetic mean, SD – standard deviation, FK – Faculty of Kinesiology students

TABLE 7
THE GRADUAL MULTIPLE REGRESSION ANALYSIS – METHOD OF GRADUAL WIDENING OF KINEMATIC PARAMETERS MODEL FOR THE GROUP OF SECOND YEAR STUDENTS OF FACULTY OF KINESIOLOGY

Significance of regression model	F-value (10.9)=41.914		
Variables	Standardized Beta regression coefficient	t-value	p-level of significance
Horizontal velocity at take-off – HVTO	1.55	2.33	*0.05
Elbow angle at takeoff – EATO	0.41	3.77	*0.00
Vertical velocity at take-off – VVTO	–0.91	–0.98	0.35
Hip angle at lowest point of center of mass – HALPCM	0.08	1.30	0.22
Shoulder angle at the highest point of center of mass – SAHPCM	–0.30	–3.90	*0.00
Shoulder angle at beginning of preparation phase – SABPP	0.21	3.03	*0.01
Landing angle – LA	0.21	1.99	0.08
Shoulder angle at the lowest point of center of mass – SALPCM	0.20	2.32	*0.05
Elbow angle at the highest point of center of mass – EAHPCM	–0.16	–1.58	0.15
Take off angle – TOA	1.24	1.17	0.27

*marked p-values significant with p≤0.05

TABLE 8
THE GRADUAL MULTIPLE REGRESSION ANALYSIS – METHOD OF GRADUAL NARROWING OF KINEMATIC PARAMETERS MODEL FOR THE GROUP OF SECOND YEAR STUDENTS OF FACULTY OF KINESIOLOGY

Significance of regression model	F-value (3.16)=34.087		
Variables	Standardized Beta regression coefficient	t-value	p-level of significance
Elbow angle at takeoff – EATO	0.39	3.80	*0.00
Take off angle – TOA	0.39	3.64	*0.00
Horizontal velocity at take-off – HVTO	0.80	6.79	*0.00

*marked p-values significant with p≤0.05

and percentage of body fat variables and the shoulder angle after takeoff (shoulder angle at the highest point of center of mass). Also, negative significant correlation was obtained between the bi-cristal diameter variable and the parameters of body segments speed prior to take off (time of achieving top hip speed before takeoff and of achieving top knee speed before takeoff) and take off phase duration, while the jump length parameter showed statistically significant positive correlation with the elbow diameter and leg length parameters, meaning that the children with longer legs and wider humerus bone achieved higher values of jump length.

Unlike the boys aged 4 to 6 years, the group of boys aged 7 to 9 years did not show statistically significant correlation between the anthropometrical variables and kinematic parameters that define knee work during the take off, but statistically significant negative correlations were obtained in the hip angle at the lowest point of Centre of mass variable and the bi-cristal diameter, body mass, back skin fold and upper arm skin fold variables. Also, positive correlations of hip angle in takeoff parameter and the body height and leg length variables were obtained, as well as negative correlations with the suprapatellar skin fold variable. Similar as the younger group of examinees, boys aged 7 to 9, with greater values of transversal skeleton dimensionality, had lower values of shoulder angle after takeoff (shoulder angle at the highest point of center of mass). The results of correlation analyses indicate that the group of examinees aged 7 to 9 years achieved greater horizontal velocity at take-off, with lower values of skin folds. Also, as the examinees were taller and more obese, the takeoff phase prolonged. The statistically significant negative correlations were obtained between the skin fold group and body fat percentage variable and the jump length parameter. The jump length caused high positive correlations with all longitudinal skeleton dimensionality variables.

Very similar results of correlation analysis between anthropometrical variables and kinematic parameters were obtained in the measured group of boys aged 10 to 12 years.

Further on, the obtained results of correlation analysis in boys aged 13 to 15 years show that some significant correlative relations between the morphological characteristics and kinematic parameters were still present. This refers to the negative correlation between the hip angle at takeoff variable and supra-patellar skin fold variable, as well as statistically significant negative correlation of horizontal velocity at take-off, vertical velocity at take-off, time of achieving top shoulder speed before takeoff, time of achieving top ankle speed before takeoff, and flight phase duration parameters with the transversal and circular skeleton dimensionality and skin folds. Unlike the previously measured groups of examinees (aged 7 to 12), significant correlations with the hip angle at the preparation phase (hip angle at the lowest point of center of mass) and the shoulder angles before and after the takeoff (shoulder angle at the lowest point of center of mass and shoulder angle at the highest point of center of mass) were not obtained. However, statistically significant positive correlation was found between the shoulder angle at the beginning of preparation phase parameter and the longitudinal skeleton dimensionality variable, as well as between knee angle at the lowest point of center of mass and the group of skin folds and body fat percentage variable.

From the results obtained for the group of adolescents aged 16 to 18, it is obvious that significant changes in the correlative relations between the anthropometrical variables and kinematic parameters occurred, however, this does not apply to younger groups of examinees. The only statistically significant relations were obtained for knee angle at the lowest center of mass variable and upper arm skin fold and body fat percentage variables, as well as the horizontal velocity at take-off variable and the elbow diameter and back skin fold variables, followed by time of achieving top shoulder speed variable and transversal and circular dimensionality and skin folds, followed by flight phase duration and leg length, and lastly, jump length parameter and transversal skeleton dimensionality variables. Unlike boys aged 4 to 15, adolescents did not show any statistically significant correlations between anthropometrical variables and the parameters defining the hip, knee and shoulder work during standing long jump, as well as takeoff angle and take off speed.

Discussion

Based on the conducted correlation analysis of anthropometrical variables and kinematic parameters a conclusion can be made. Regarding the group of twenty-year-old students of Faculty of Kinesiology the most efficient performance of standing long jump performance was achieved by the examinees with the mesomorph body type who, because of their better physical characteristics, had better predispositions for achieving the coordinate relations of individual body segments, what was concluded by the researches[24,25]. Further on, based on the obtained results of correlation analysis it can be concluded that boys aged 4 to 6, with stronger stature and more subcutaneous fat tissue, did not achieve favorable knee dynamics and they achieved lower values in shoulder and knee angles, meaning lower efficiency of the mentioned segments during standing long jump; while children with longer legs were more efficient. Similar results, using the sample of preschool children, were obtained by many researchers[26–28], who concluded that there was a significant difference of body status and motor abilities (among which was the observed standing long jump), that is, they determined that obese children achieved weaker results of measured motor abilities than their peers with normal body weight and desirable body built, and that taller children with longer legs had longer standing long jump[29], what was not the case in the population of students[30].

From the results of relation between anthropometrical variables and kinematic parameters in examinees aged 7 to 9 years, it is possible to conclude that boys who were more obese made a lower bend forward in the preparation jump phase, and in the moment of takeoff they did not manage to stretch their body to an adequate degree, what influenced standing long jump result negatively, while taller and skinnier boys achieved larger hip angles in the moment of takeoff, resulting in greater jump efficiency. Almost identical results of relation between hip and joint angle before takeoff were obtained by[31], based on which they concluded that jump length was positively correlated with somewhat greater initial hip, knee and ankle angle in the preparation phase of jump, or, negatively correlated with low squat and great front bend, because in this way the countermovement of leg segments was disabled, or, the intersegment coordination in preparation phase of jump was disturbed. Also, in boys aged 7 to 9 high positive correlations of jump length and all the variables of skeleton longitudinal dimensionality were obtained, what was affirmed in researches by[19,29]. Based on the obtained results a conclusion can be made, boys aged 7 to 12, with larger values of transversal skeleton dimensionality, skin folds and body fat percentage, achieved lower values of hip and shoulder angle, lower horizontal velocity at take-off and shorter jump length, unlike the children with normal body mass and body stature. Also, taller examinees, with longer arms and legs jumped longer, what was concluded by studies of relation between morphological characteristics and motor variables by[32,33]. Further on, the correlation analysis results in boys aged 13 to 15 showed that examinees with more subcutaneous fat tissue and body fat percentage did not squat during the preparation phase of long jump. Also, boys that were taller, with longer arms and legs had greater amplitudes (greater retroflection) in the shoulder joint at the very beginning of preparation phase, and from the correlation relations with the jump length parameter it is obvious that they achieved greater values of jump length, unlike boys aged 13 to 15 with greater body mass. Also, unlike the previous groups of examinees, a statistically significant negative relation between take off angle parameter and body height, arm length, elbow diameter and body mass variables occurred. This means that taller and heavier boys achieved lower take off angle. Based on the mentioned facts a conclusion can be made, morphological characteristics have significant role in achieving efficient standing long jump performance. Namely, children that are shorter and more obese are limited at the very beginning and it can be assumed that the length of their jump would be shorter than in taller and lighter children, with less subcutaneous fat tissue, what was concluded by researches by[34,35]. From the correlative relation between the morphological characteristics and kinematic parameters in group of adolescents of this research, it was concluded that, similar as in students of Faculty of Kinesiology, the standing long jump efficiency was mostly influenced by transversal skeleton dimensionality, skin folds and body fat percentage parameters[30,36], that is, the examinees of stronger stature and greater body mass did not squat low enough in the lowest point of center of mass before takeoff, had lower horizontal velocity at take-off and shorter jump length, unlike the lighter jumpers[9,11,37].

Conclusion

The standing long jump test is a complex motor movement in which the jumper has to, in order to achieve the optimum performance, perform a coordinated hand movement, front bend, half-squat, lean, take off with both legs and landing; the jump efficiency depends on the number of factors of which the following are the most important: upper and lower body segment coordination, motor knowledge, familiarization and growth, development and maturation.

In this sense, this research determined relations between certain morphological characteristics and kinematic parameters relevant for standing long jump performance. The conclusion can be made: length of the long jump in adult athletes is mostly influenced by body mass, subcutaneous fat tissue and body fat percentage, while in younger age groups, besides the mentioned measures, the examinees who are taller, with longer arms and legs achieve better jump length values. The results obtained in this research are useful and important for the more objective evaluation of motor abilities quality in children and adolescents, programming the work in the area of kinesiology and individualization of work in physical education classes and other kinds of organized bodily exercise regarding the choice of tests adequate for a certain age.

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POVEZANOST IZMEĐU ANTROPOMETRIJSKIH KARAKTERISTIKA I KINEMATIČKIH PARAMETARA KOJI UTJEČU NA EFIKASNOST SKOKA U DALJ IZ MJESTA KOD DJEČAKA I ADOLESCENATA

S A Ž E T A K

Cilj ovog istraživanja bio je utvrditi povezanost između antropometrijskih varijabli i kinematičkih parametara koji utječu na efikasnost skoka u dalj iz mjesta kod dječaka i adolescenata u dobi od 4 do 18 godina i studenata druge godine Kineziološkog fakulteta. Uzorak ispitanika sastojao se od 120 osoba muškog spola podijeljenih u 5 eksperimentalnih skupina po 20 entiteta dječaka i adolescenata (od 4 do 6, od 7 do 9, od 10 do 12, od 13 do 15, od 16 do 18 godina starosti), te jednu kontrolnu skupinu koju je činilo 20 studenata druge godine Kineziološkog fakulteta. Uzorak varijabli činio je 21 kinematički parametar, relevantni za efikasnu izvedbu skoka u dalj iz mjesta, zatim baterija od 13 morfoloških karakteristika te dob ispitanika. Ovim istraživanjem utvrđena je povezanost određenih morfoloških karakteristika i kinematičkih parametara relevantnih za izvedbu skoka u dalj iz mjesta. Može se zaključiti da je na dužinu skoka kod odraslih primarno utjecala tjelesna masa, potkožno masno tkivo i postotak tjelesne masti, dok kod mlađih dobnih skupina, izuzev navedenih mjera, ispitanici koji su bili viši te imali duže noge i ruke su postigli bolje rezultate.