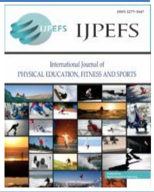
FULL LENGTH ARTICLE

DOI: 10.26524/ijpefs1814

International Journal of
PHYSICAL EDUCATION, FITNESS AND SPORTS



Connection between morphological characteristics and vertical jump stiffness of Female volleyball players

Received 6th February 2018
Accepted 29th February 2018

www.ijpefs.com

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Abstract: Research was conducted on the sample of 73 female participants, members of volleyball clubs "Jahorina" from Pale and "Student", aged 10-16 (younger pioneers N=35 and pioneers-cadets N=38). Younger pioneers had been involved in the training process for 1 year whereas pioneer-cadet female participants had been involved in the training process for at least three years. Morphological characteristics were measured on entire sample using the IBP procedure, as well as the vertical jump stiffness assessment using the device 'Just Jump System' aim of this research was to determine the connection between anthropometrical variables and jumping performances of female volleyball players. Linear regression analysis results suggest that predictor system of the anthropometrical variables had no statistically significant connection with the criteria in both sub-samples. Common variable in both cases was in very low percentages. Research results suggest that the assessment of muscle strength in explosive motor tasks is independent from the body size and activities of morphological characteristics.

Key Words: anthropometry, explosive strength, plyometrics, relationships, Just Jump System

1 Introduction

Sport is activity comprised of competition, specific preparation for competition, specific relations and connections related to the overall activity [1]. In the course of life human body undergoes progressive changes regarding motor abilities [2]. A child completes different levels of motor activities which depend on mechanic demands and morphological characteristics which can be represented by movement patterns and which depend on the mechanical demands and morphological characteristics. Success in volleyball certainly depends on morphological characteristics, the basic ones being height and mass and which are valorised depending on the current age of volleyball players [3]. Muscle strength in volleyball actions are characterised by four types of muscle activities: isometric, concentric, eccentric and plyometric contraction. The first type of the contraction is defined as static strength and others as dynamic strength. Explosive strength is expression of maximum strength in the shortest possible amount of time [4]. This type is dominant in volleyball because this sport is comprised of jumps and rapid changes of movement direction. Jumping ability is one of the limiting success factors in volleyball and it is therefore necessary to provide for its better development and even more accurate measurement. Jumping efficiency primarily depends on the speed, height and timing of the jump. In the muscle system, the ratio between fast and slow muscle fibers and elasticity of muscles and tendons is crucial. If fast muscle fibers are dominant, the consequence is the higher level of strength development. Main characteristic of muscle and tendon elasticity is utilisation of elastic energy in eccentric – concentric cycle. Contribution of elastic characteristics of muscle-tendon joint depends on the speed of that transition. The transition needs to be as short as possible, in any case shorter than 260 milliseconds [5, 6]. Papers focused on vertical jump regarding performances suggest separate tests of characteristics for various age groups [7], followed by morphological characteristics which may largely influence the performances [8], as well as gender and hereditary markers [9]. Many trainers find that vertical jump is important skill which contributes higher performances in many sports including football, basketball and volleyball [10, 11]. Some authors find that the vertical jump is a performance of muscle strength of lower extremities [12, 13, 14], whereas others find the vertical jump to be measurable coordinated activity [15, 16, 17, 18].

Aim of this study was to determine whether there is a connection between the system of predictors (anthropometric variables) with the criterion – vertical jumping ability in children of two age categories comprised of younger pioneers and pioneer cadet female subjects..

2 Method

Empirical method was used in the research. The research was transversal which means that only one measurement was performed on the sample of female volleyball players from Pale, East Sarajevo.

The sample was comprised of the volleyball players from the volleyball clubs "Jahorina" from Pale and "Student", aged 10 – 16, total number of 73 (younger pioneers N=35 and pioneer-cadet female participants N=38). The participants have different social status, they are healthy individuals with no mental disorders. Younger pioneers are training volleyball for at least one year and the sub-sample of pioneer cadets is training for at least three years.

For the purpose of this research a battery of tests was designed and it was comprised of morphological characteristics, and the sample of variables included the morphological characteristics for volleyball under the recommendation [19] and motor abilities test for vertical jump. Anthropometric measures which could significantly influence the expression of vertical jump in volleyball players were selected (they will represent the predictor variables in this paper) as follows: for the assessment of longitudinal dimensionality of the skeleton: AVIS – body height (cm), ARAR – arms span (cm), AMAS – body mass (kg), ASON – medium upper arm circumference (cm), ASOP – medium forearm circumference (cm), ASONK – medium thigh circumference (cm), ASOPK – medium calf circumference (cm), AKNN – upper arm skinfold (mm), AKNL – skinfold on the back (mm), AKNS – suprailiac skinfold (mm), AKNT – belly skinfold (mm), BMI - Body mass index (kg/m2), VS – vertical jumping ability (cm). Nutritional index was indirectly calculated using the following equation:

$$\mathbf{BMI} = \frac{\text{Body mass (kg)}}{\text{Body height (m)}^2}$$

BMI (kg/m^2)(Body mass index), and nutrition status categorisation was performed using the Harrison scale and it is depicted in table 1.

Table 1 BMI categorisation according to Harrison [20]

BMI	kg/m^2
BMI	Category
<16	Severe thinness
16-16.9	Moderate thinness
17-18,4	Mild thinness
18.5-24.9	Normal range
25-29.9	Pre-obese
30-39.9	Obese
>40	Morbid obesity

Morphological characteristics were measured in accordance with the IBP standards for each dimension. Anthropometer by Martin, decimal digital scale, metal measuring tape with centimetre scale and Jon Bull calliper were used for measuring anthropometric characteristics.

Motor ability of the stretching explosive strength of legs was measured by the test: Vertical jumping ability (cm). Vertical jump was performed from the standing position, with remark that the legs were stretched in the knee joint, arms were free and positioned alongside the body (Figure 1). Child would jump high, with maximum strength and with strong arms' swing. Measuring was performed using the *Just Jump System (Probotics, Huntsville, AL, USA), w*hich is a computer device for measuring the height of vertical jump. This is one of the most commonly used and most practical means for measuring the vertical jump height. The instrument is based on the manner of interrupting the continuous circuit built inside the rubber platform with dimensions 69 x 69 cm. the platform detects the absence of test subject or the presence on the plate according to time spent doing the jump after which the program calculates other jump-related values. In addition to the jump height this instrument also calculates the time required for single jump and average height and time for four jumps (Figure 2). Computer can memorise up to 60 consecutive jumps. This measuring device is extremely accurate and eliminates the assumption factor. Jump height assessment requires strict following of the technique of performing the test; both feet must leave and land on the platform simultaneously, knees must be stretched, and upper body must also be stretched. The participants were explained the protocol in detail after which the practical part commenced. Each participant had one test-try followed by three more tries. Only better result was used for further analysis. According to the author, Just Jump System gives reliable and accurate results [21, 22].

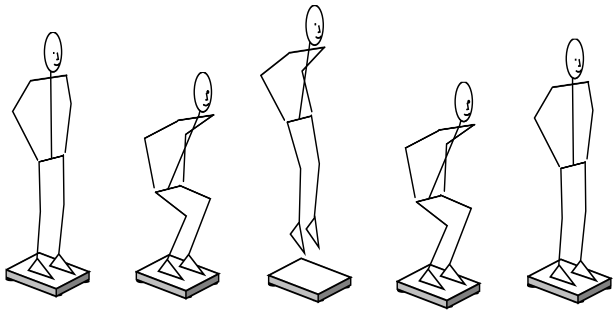

Figure 1 Jump demonstration in phases.

Picture 2 Instrument Just Jump System.

Descriptive statistics were performed for all the analyzed variables: arithmetic mean (AS), standard deviation (S), minimal (MIN) and maximal (MAX) values, variation coefficient, Sk – skewness (of the distribution) and kurtosis (of the distribution). Linear regression analysis was performed for the purpose of establishing the influence of system of predictor variables on vertical jumping ability, being a single contribution of the predictors to the defining of the criteria.

3 Results

Values of descriptive statistics (Table 2) indicate the homogeneity of sub-sample of younger pioneers female volleyball players in the variables showing the skeleton longitudinality: body height, arms span; variables used for assessment of body volume: body mass, medium upper arm circumference, medium forearm circumference, medium thigh circumference. Similar nutrition level was also observed in younger pioneers using the BMI values. Bearing in mind the Harrison categorisation younger pioneers fall into the category of normal range, meaning that there is healthy balance between their height and body mass. In all the variables used for assessment of subcutaneous fatty tissue for the analyzed sub-sample, greater variability of results was observed, which indicates greater variations in the measures analyzed. Differences between minimum and maximum values of the results are high. This is a consequence of different influences of socio-economic conditions to the development of body.

In case of the second analyzed sub-sample, pioneer-cadet female volleyball players (Table 2), we can observe similar level of skeleton longitudinality development (height, arms span), values of variables derived from them, body volume variables (body mass, medium upper arm circumference, medium forearm circumference, medium thigh circumference). In all the variables regarding the assessment of subcutaneous fatty tissue greater differences on individual level were observed in values and they were caused by exogenous factors. Observing the BMI values, participants of pioneer-cadet age are in normal range.

Observing the values for skewness and kurtosis, the variables do not divert from normal distribution. Pronounced leptokurtosis was observed for the variable Suprailiac skinfold in the sub sample of pioneer cadets.

In the criteria for assessment of explosive strength of legs (Table 3) – Vertical jumping ability, morphological variables system was not statistically connected to the criterion on the level of significance in the sub-sample of younger pioneers (P=0.45), nor in the sub sample of pioneer – cadets (P=0,21). Values of the coefficient of multiple correlation were similar (R=0.65 and R=0.66), which described 42%, and 43% of common variability (observing the adjusted values of determination coefficient that variability is even lesser, only 2, or 8%). If we take into consideration the sample size, variability points out to the fact that some other characteristics have greater influence on this specific motor ability.

4 Discussions

Test of vertical jump is one of the most common assessment methods in sport [23]. This type of jump is in great correlation with the strength of leg stretchers. This type of vertical jump assessment is considered a referential standard in this type of measurements. Sensor platforms have been in wide use for a long period of time for the purpose of jump height assessment and efficient scientific analysis.

Table 2. Descriptive statistics for both age groups

Var.	Club status	MIN	MAX	AS	S	Skew	Kurt	CV (%)
AVIS	MP	149.70	187.10	170.92	8.69	-0.21	-0.10	5.08
	PK	137.60	176.60	158.76	11.28	-0.11	-1.18	7.09
ARAR	MP	151.00	191.00	173.74	9.70	-0,.21	-0.36	5.58
	PK	140.00	181.00	161.97	12.73	-0.18	-1.14	7.86
AMAS	MP	42.80	78.20	60.79	8.52	-0.18	-0.37	14.02
	PK	28.30	76.50	48.07	12.11	0.49	0.02	25.19
ASON	MP	20.30	30.40	24.90	2.42	0.46	-0.20	9.72
	PK	17.30	32.90	22.91	3.12	0.78	1.52	13.62
ASOP	MP	20.40	25.50	23.16	1.33	-0.01	-0.66	5.74
	PK	17.50	27.70	21.63	1.94	0.34	1.64	8.97
ASONK	MP	45.80	63.20	55.55	4.42	-0.33	-0.69	7.96
	PK	38.20	65.50	50.04	6.25	0.36	0.32	1.,49
ASOPK	MP	29.90	40.20	36.17	2.60	-0.54	-0.18	7.19
	PK	26.20	41.60	32.75	3.61	0.19	-0.13	11.02
AKNN	MP	6.00	21.10	11.77	3.64	0.91	0.39	30.93
	PK	7.40	27.30	13.16	4.53	1.16	1.27	34.42
AKNL	MP	5.80	17.60	9.62	3.26	1.02	0.13	33.89
	PK	3.60	24.80	7.86	3.64	2.91	12.17	46.31
AKNS	MP	3.20	28.20	9.41	4.88	1.93	5.60	51.86
	PK	3.40	24.40	8.58	5.18	1.44	1.62	58.46
AKNT	MP	8.70	40.00	17.21	7.02	1.32	2.20	40.79
	PK	4.40	41.20	15.29	9.39	1.23	0.92	61.41
BMI	MP	16.60	25.10	20.78	2.30	0.24	-0.68	11.07
	PK	14.40	29.40	18.79	2.95	1.34	3.49	15.70
VS	MP	219	250	23.91	7.74	-0.70	0.70	3.24
	PK	214	250	23.10	8.34	0.19	-0.12	3.61

Legend: MP – younger pioneers; **PK** – pioneer – cadets; **AS** – arithmetic mean; **S** – standard deviation; **MIN** – minimal measuring result; **MAX** – maximum measuring result; **Skew** – skewness (of the distribution results); **Kurt** – kurtosis (of the distribution results): **CV** – variation coefficient.

Table 3.Regression analysis results for Vertical jumping ability (VS)

Var.	**Younger pioneers**				**Pioneer - cadets**			
	r	**p**	**Beta**	**pbeta**	**r**	**p**	**Beta**	**pbeta**
AVIS	0.28	0.05	1.33	0.57	0.13	0.21	-1.15	0.41
ARAR	0.21	0.11	-0.16	0.78	0.13	0.22	-0.24	0.61
AMAS	0.39	0.01	0.45	0.87	0.20	0.12	0.95	0.71
ASON	0.24	0.09	0.14	0.83	0.21	0.10	2.35	0.03
ASOP	0.11	0.27	-1.03	0.06	0.13	0.22	-1.26	0.15
ASONK	0.33	0.03	-0.09	0.90	0.21	0.11	0.71	0.41
ASOPK	0.26	0.07	0.06	0.90	0.18	0.13	-0.40	0.56
AKNN	0.07	0.35	-0.05	0.85	0.02	0.46	-0.17	0.67
AKNL	0.45	0.00	0.33	0.37	0.03	0.44	-0.41	0.45
AKNS	0.17	0.17	-0.04	0.92	0.01	0.48	-0.56	0.48
AKNT	0.21	0.11	0.01	0.99	0.01	0.50	-0.20	0.84
BMI	0.23	0.10	0.64	0.80	0.17	0.16	-0.60	08
R	0.65				0.66			
R^2	0.42				0.43			
Pril. R^2	0.02				0.08			
P	0.45				0.21			

Legend :**r** – Pearson correlation coefficient; **p** – statistic significance level for r; **Beta** – regression coefficient; **pbeta** – significance level of regression coefficient; **R** – multiple correlation coefficient; **R^2**- determination coefficient; **Pril.R^2**– determination coefficient adjusted for small samples; **P** – significance level of multiple correlation.

Incorrect performing of vertical jumps may cause orthopaedic complications on the knees of not only children but also athletes [24]. From the physiological aspect this term can be defined as maximum activation of motor units in the unit of time. This type of strength is part of strength system and it may be observed as a system where a leading role of an element will determine the type of explosive movement. Element of the system is reactive ability of movement based on the myotatic reflex, i.e. the stretching reflex. This reflex is a strong contraction which follows the stretch of the muscle. Explosive strength manifested in the reactive ability may be divided into category of plyometric and pneumatic explosive strength. Mechanism of expressing the plyometric and pneumatic strength is the same except it is necessary to provide amortisation for greater force in case of the latter.

Research verified that the angle formed by thigh and lower leg was not identical for all the female volleyball players because they assumed the semi-squat position themselves. Maybe the processes of manifestation of jumping ability was influenced by previous activities in form of warming-up and raising the working temperature of the same groups of volleyball players because warm-up was performed at will. Manifestation of maximum nerve-muscular joint action can be a consequence of muscle length and its maximum movement amplitude, so in the future research it would be recommendable to take into consideration the length of lower leg and thigh, as well as exact angle between femur and tibia during the jump with arm swing and reactive transfer of the swing to the body, because the arms provide the impulse for uplift. From the physiological aspect explosive strength depends primarily from: intensity of stimulus to the cortex, permeability of the motor synapses, transmission speed of the impulse from the centre to the periphery of the effector, number of active motor units and bio-chemical composition of the muscles. It equally depends on the bio-mechanical movement characteristics which refers to the length of levers and movement amplitude. Muscle strength tests' category focuses on the measuring of the performance capacity of the muscles or muscle groups in producing power. Aim of the tests is measuring different elements of muscle activity, from the ability to generate power at great speeds to production of power by isometric contraction and measuring maximum strength. Each manifestation of muscle power demands engagement of both central and peripheral neural processes so test achievements depend on many factors (for example, speed of hydrolysis of adenosine-triphosphates (ATP), muscle cross-section, contraction and signal translation speed, degree of recruitment of motor units, triggering synchronisation etc.). as the tests should be standardised by defining the position of body part and entire body (in order to make the result for specific muscle or group of muscles isolated and specific) and by defining the measuring angle and force - the speed, it is necessary to have a special neural program [25]. Consequences of this are two implications – pattern for specific movement must be specific and correctly learnt or the task would not reflect the muscle capacity. Furthermore, the rigorous standardisation is crucial for the objective measuring, it provides for the evaluation of highly specific neuro-muscular function. Individual sport movements (like jumps or throws) are comprised of series of fast, short-lasting concentric contractions which are instantly followed by eccentric contractions of the same muscle group (the so-called *stretch-shortening* cycle). Besides isometric, isotonic, isoinertial and isokinetic measurements of strength and power, it is necessary to measure achievement under these conditions mainly by testing various parameters of vertical jump lon specially designed dynamometers which measure force, power and work generated in the course of jump [5]. Research results are not in line with the findings of previous research performed by majority of authors who dealt with this issue, for example [26]. The author points out the significant influence of morphological characteristics of young female volleyball players on the manifestation of motor abilities such as jump, which was not observed in this specific case from the values of coefficients of determination and total common variant, which was confirmed by the linear regression analysis. The results obtained did not confirm the previous findings on the significance of individual dimensions of status of bio-morphological characteristics on the efficiency on women's volleyball [27]. In majority of research performed on adolescents, as in [28, 29] it was evident that the subcutaneous fatty tissue had negative influence on explosive strength and power movements, which was not observed in our research. Research results [20] have shown that orientation and primary selection in women's volleyball should be performed according to morphological characteristics (greater longitudinality of skeleton and lower percentage of subcutaneous fat) and motor abilities: speed, repetitive strength of upper body muscles and flexibility. Volleyball training may influence the development of muscles and strength factors, also the explosive strength of jumps and/or high jumps, which is, alongside with height, differentiated in female volleyball players aged 10 to 12, but also a bit older (pioneer-cadets). Quality of selection will have the dominant influence on the outcome of top volleyball players.

5 Conclusions

Research results are not in line with the expectations of the authors. Justification for the results, being the fact that there is no connection between morphological characteristics and vertical jumping ability, the authors find in the predictions of the theory of geometric resemblance and suggest that lab measuring of muscle strength of stretchers can be replaced by measuring the height of jump. If these results get the confirmation in other explosive movements (for example, sprint, hit, throw) and other samples, we would be able to make the general conclusion that results in explosive motor tasks (jump, sprint, throw and hit) assess muscle strength independently from the size of body and influence of morphological characteristics.

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