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Metric Characteristics of some Jumping Abilitiy Tests in Boys – Differences between Volleyball and Non-Volleyball Players

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Original scientific paper

Abstract
Thirty-nine boys (28 non-volleyball players and 11 volleyball players) were tested by the Powertimer machine with the aim of analyzing the metric characteristics of jumping ability tests. Squat jump tests (SJ) were used on the examinees, as well as countermovement jump (CJ) and approach jump tests (AJ). Good metric characteristics of all tests have been established (reliability, sensitivity, homogeneity and validity). Both groups of examinees showed very little difference of jump height in the CMJ test, in relation to the SJ test (less than 1 cm). Inefficient transition from the eccentric to the concentric muscle action, as well as the usage of preparatory movements, even in the static position test (SJ), was the possible cause of these results. The differences of the results in AJ and CMJ tests are 6 cm in non-volleyball players and 11 cm in volleyball players. The volleyball players achieved significantly higher results in all tests in relation to the non-volleyball players, especially in AJ test. In SJ and CMJ tests volleyball players jumped on average 4 cm higher than the non-volleyball players, while the difference in the AJ test was 9 cm. The applied tests can be used in lower body strength evaluation in the non-volleyball players sample, but bearing in mind that in young volleyball players strength differentiation sets in – the elastic and the explosive components appear, that should be tested separately.

Key words: **volleyball, powertimer, reliability, homogeneity, validity**

Sažetak
S ciljem analiziranja metrijskih karakteristika testova skočnosti, kao i značajnosti razlika između neodbojkaša i odbojkaša, 39 dječaka (28 neodbojkaša i 11 odbojkaša) testirano je na Powertimer uređaju. Ispitanici su izmjereni s testovima squat jump (SJ). countermovement jump (CJ) i approach jump (AJ). Utvrđene su dobre metrijske karakteristike svih testova (pouzdanost, osjetljivost, homogenost i valjanost). Kod obje grupe ispitanika utvrđene su vrlo male razlike u visini skoka u testu CMJ u odnosu na test SJ (manje od 1 cm). Neučinkovit prelaz iz ekscentrične u koncentričnu mišićnu akciju, kao i korištenje pripremnih pokreta i u testu iz statične pozicije (SJ) mogući su razlozi takvih rezultata. Razlike između rezultata u testovima AJ i CMJ su 6 cm kod neodbojkaša i 11 cm kod odbojkaša. Odbojkaši su u svim testovima postigli značajno bolje rezultate u odnosu na neodbojkaše, a naročito u testu AJ. U testovima SJ i CMJ odbojkaši u prosjeku više skaču od neodbojkaša 4 cm., a u testu AJ 9 cm. Primjenjeni testovi mogu se koristiti za procjenu snage nogu na uzorku neodbojkaša, ali kod mladih odbojkaša početnika dolazi do diferencijacije snage na elastičnu i eksplozivnu komponentu koje treba zasebno testirati.

Ključne riječi: **odbojka, powertimer, pouzdanost, homogenost, valjanost**

Introduction

Power is one of the most important biomotor abilities in volleyball, and vertical jumping ability is its most important manifestation (Jurko et al. 2008, Borras et al. 2011, Grgantov et al. 2013, Milić et al. 2013). For a long time, jumping ability in volleyball was estimated exclusively by standing vertical jump or from a volleyball approach from wall or vertec measuring scales. The advantage of such tests is their specificity, and the disadvantage is the impossibility of analyzing certain jumping ability components (concentric component, elastic component, arms attribution, volleyball approach influence etc.). These are the reasons why during the last few decades different diagnostic apparatus are being increasingly used (ergo jump, just jump, power timer, opto jump, IR-mat etc.), which can also estimate the vertical jumping ability (Hoffman and Kang 2002, Bosquet et al. 2009, Enoksen et al. 2009, Glattthorn et al. 2011, Nuzzo et al. 2011). Tests for estimation of certain jumping ability components have been constructed using these systems (squat jump, counter movement jump with and without arm swing, drop jump, etc.). Past research had also confirmed good metric characteristics of the mentioned tests (Marković et al. 2004, Caruso et al. 2010). Most of the past volleyball research have analyzed certain jumping ability components and metric characteristics of the evaluation test, using the sample of senior players. However, jumping ability evaluation is not important only in adult athletes. Very useful information for the training process and the process of selection can be obtained by the analysis of certain

jumping ability components in youth volleyball players, as well as in children who are not in volleyball training yet, while their volleyball potential should be estimated by tests. The available references show that the authors did not find a single research that analyzed the metric characteristics of the vertical jumping ability tests (squat jump, countermovement jump and approach jump) on the population of young volleyball players and non-volleyball players.

Therefore, the basic aim of this research was to analyze metric characteristics of the vertical jumping ability estimation tests on the Powertimer device using the sample of young boys. The special aim was to analyze the differences of these tests results in young volleyball players and non-volleyball players.

Materials and Methods

Participants: The research was conducted on the sample of 39 boys, aged 11 to 13, participants of Kaštela mini volleyball championship. From the total number of examinees, 28 boys have never practiced volleyball (non-volleyball players), while the remaining 11 boys have actively practiced volleyball in Mladost volleyball club in Kaštela (volleyball players), 3-4 times a week in the period of 2-3 years.

Apparatus: The examinees were tested on the Powertimer portable device, made by a Finnish sports testing devices manufacturer Newtest. The device consists of a mat with sensors, a data collecting console, and a program package on the portable computer that automatically processes and saves data. The device measures the time from the moment the examinee leaves the mat until the next contact with the ground. Prior to the test, the examineežs body mass was entered into the program, so that the device was able to calculate the height and the power of the jump.

The results of the following tests were measured:

1. Squat jump: The examinee was standing on the contact mat in a squat position (the angle between the lower body and thigh was 90 degrees, the trunk was as erect as possible, and the hands were akimbo). After 3 seconds in that position the examinee attempted to jump as high as possible by straightening his lower body. The landing was performed with lower body as straight as possible.
2. Countermovement jump (CMJ): The examinee was standing on the contact mat with his lower body straight and arms akimbo. From this position he lowered himself to a squat position (position described in the first test) and immediately jumped upwards by straightening his lower body. The landing was performed as described in the first test.
3. Approach jump (AJ): After performing a take-off following a three steps approach the examinee jumped onto the contact mat with two feet and jumped as high as possible using the arms swing as well. The landing was performed as described in the first two tests.

More detailed instructions on the correct performance of the test can be found in a research by Acera et al. (2011). Each examinee performed a standardized 15-minute warm-up consisting of general movements and dynamic and static stretching, prior to the testing. Each test was performed three times with 2-3 minutes pauses between the repetitions.

Procedures: The reliability of the measuring instruments was analyzed based on the test items intercorrelation matrix. Also, an inter-item correlation and Cronbach alpha coefficients have been calculated. The homogeneity of the measuring instruments was confirmed based on the analysis of variance between the items. Distribution normality was tested by applying the Kolmogorov-Smirnov test (KS). Basic descriptive statistic indicators have been calculated on the condensed variables (the best results in three test repetitions have been chosen): mean (M), standard deviation (SD) and maximum result (MIN and MAX).

Factor validity of the jumping ability estimation measuring instruments was established using the factor analysis of the principal components, according to Guttman – Kaiser criterion, and by correlation analysis - the degree of relation between the jumping ability estimation variables. Pragmatic value of the measuring instruments was established by using variance analysis of the observed groups (non-volleyball players - volleyball players).

Results

The results displayed in Table 1 show that all the variables were highly reliable, based on the Cronbach alpha value and inter-item correlation. The jumping ability evaluation tests were somewhat more reliable in the volleyball players sample than in the non-volleyball players. The lowest correlations between the items were observed in the CMJ test on the sample of non-volleyball playing boys.

Table 1. Item intercorrelation and values of reliability coefficients for all the applied variables in male non-volleyball players (N=28) and male volleyball players (N=11)

Variables	NON-VOLLEYBALL PLAYERS		VOLLEYBALL PLAYERS	
	CA	IIR	CA	IIR
SJ	0,87	0,73	0,93	0,88
CMJ	0,81	0,59	0,97	0,93
AJ	0,92	0,81	0,97	0,94

SJ – squat jump; CMJ – counter movement jump; AJ – approach jump; CA - Cronbach alpha coefficient ; IIR-average inter-item correlation

Table 2 shows the average results of certain test items. The significance of the result difference between the measuring items in certain tests was tested by the analysis of variance.

Based on the gained results, a conclusion can be made – all jumping ability tests in both subsamples showed good homogeneity.

The obtained results of the KS test (table 3) were lower than the limit values, leading towards the conclusion that the tested variables distribution did not differ significantly from the normal distribution. Since this was the case, further analysis could use parametric methods of data analysis. The T-test determined significant differences between the volleyball players and the non-volleyball players. Both groups of examinees showed very little difference in jump height in the CMJ test in relation to the SJ test (less than 1 cm). The difference in jump height between the AJ and CMJ test was higher; in non-volleyball players it was somewhat less than 6 cm, and in volleyball players it was above 11 cm. The volleyball players achieved significantly better results than the non-volleyball players in all tests, and especially in AJ test. The SJ and CMJ tests showed that volleyball players on average jump more than 4 cm higher, and in the AJ test more than 9 cm higher than the non-volleyball players.

Relatively high correlations between the tests on the non-volleyball players subsample showed that these tests probably measured the same latent dimension (motor ability), which was also confirmed by factor analysis. This factor can be called lower body strength. However, squared values of the correlation coefficient showed that less than 30% of variance of one variable had been explained by another variable, which was not sufficient for a claim that they had a mutual object of measuring. High correlation was obtained between the AJ and the CMJ test in the sample of volleyball players, as well as low correlation between the SJ test and the CMJ and AJ tests. Therefore, it was no surprise that factor analysis resulted in two factors. High projections onto the first factor, explaining the 58% of the overall variance of the system, were noticed in the CMJ and AJ tests. Both tests showed a transition from the eccentric to the concentric muscle action, so this factor can be called lower body reactive power. Only the SJ test, characterized by concentric contraction, had a high projection onto the second factor, and can be called lower body explosive power.

Table 2. Analysis of variance for the test items in male non-volleyball players (N=28) and male volleyball players (N=11)

Variables	NON-VOLLEYBALL PLAYERS					VOLLEYBALL PLAYERS				
	M1	M2	M3	F	p	M1	M2	M3	F	p
SJ	26,80	26,38	26,76	0,30	0,74	31,33	31,53	31,16	0,18	0,84
CMJ	26,73	28,12	27,45	1,48	0,24	31,85	31,56	31,01	1,82	0,19
AJ	33,81	33,25	33,32	0,65	0,53	42,84	43,10	42,43	0,70	0,51

M1-M3 –means of certain test items; F-F test; p- significance level

Table 3. Descriptive indicators, sensitivity and significance of differences of the applied tests between the non-volleyball players and the volleyball players

Var.	NON-VOLLEYBALL PLAYERS					VOLLEYBALL PLAYERS						
	M	MIN	MAX	SD	KS*	M	MIN	MAX	SD	KS**	t-test	p
SJ	26,65	18,24	32,84	3,70	0,10	31,34	26,67	36,57	3,52	0,20	13,00	0,001
CMJ	27,43	21,23	37,23	4,00	0,17	31,47	24,46	36,66	3,77	0,19	8,32	0,007
AJ	33,47	24,37	40,20	4,06	0,10	42,78	31,00	50,16	5,17	0,23	35,67	0,000

M –mean; MIN – minimum result; MAX – maximum result; SD – standard deviation; KS – Kolmogorov-Smirnov distribution normality test; * - limit value of the KS-test for N=28 is 0.25; **- limit value of the KS-test for N=11 is 0.39

Table 4. Correlation between the tests and their latent structure on the subsamples of non-volleyball players and volleyball players

Variables	NON-VOLLEYBALL PLAYERS					VOLLEYBALL PLAYERS				
	SJ	CMJ	AJ	F1		SJ	CMJ	AJ	F1	F2
SJ	1,00	0,48	0,56	-0,82	SJ	1,00	0,22	-0,30	0,10	0,99
CMJ	0,48	1,00	0,57	-0,82	CMJ	0,22	1,00	0,75	-0,92	0,35
AJ	0,56	0,57	1,00	-0,86	AJ	-0,30	0,75	1,00	-0,95	-0,23
EXPL.VAR				2,07					1,75	1,15
PRP.TOTL				0,69					0,58	0,38

F1 and F2 – components obtained by factor analysis; EKSPL: VAR.- explained component variance; PRP.TOTL.- proportion of the explained component variance.

Discussion

The basic aims of this research were: to establish metric characteristics of the jump ability tests using the powertimer device, and to determine the significance of differences between junior male volleyball players and junior male non-volleyball players. Good metric characteristics of all tests have been established (reliability, sensitivity, homogeneity and validity). Good test homogeneity indicated the fact that the learning process and fatigue did not influence the results. The authors assumed that they would observe a trend of result growth in non-volleyball players from the first item to the third one in the AJ test, however, this never occurred. It is not to be expected for the junior male non-volleyball players to stabilize their performance after only several trial attempts. It is more probable that, due to the complexity of the performance, such a low number of attempts did not result in intermuscular coordination improvement. Therefore, future research should dedicate 1-2 training sessions to the perfection of the two foot takeoff performance after the volleyball approach in junior male non-volleyball players. This way, the possibility of the performance technique affecting the tests results would be significantly lowered.

Based on the results obtained by correlation and factor analysis a conclusion can be made that the applied tests can be used in lower body strength evaluation on the sample of non-volleyball players, but also that strength differentiation occurs even in young volleyball players, resulting in elastic and explosive components, which should be separately tested. The pragmatic validity of the test was confirmed by their ability of distinguishing volleyball players from the non-volleyball players.

The comparison of the results of the tests applied on young volleyball players and non-volleyball players showed that young volleyball players had significantly better results in the tests. This is probably a consequence of the selection process, and partially of the influence of the training process, which develops vertical jumping ability by performing a great number of repetitions. In relation to the data obtained on the sample of adult athletes (Hara et al. 2008, Borras et al. 2011), young volleyball players and non-volleyball players in this research had a less expressed result growth in the CMJ test, in relation to the SJ test. Mastelić et al. (2012) obtained a very similar results growth trend on the sample of young female volleyball players. Harman et al. (1990) explained better jumps after the preparation (CMJ) in contrast to the jumps from the fixed position (SJ) by a higher level of lower leg stretching muscles activation and a higher level of force generated in the eccentric phase, fully expressed in the concentric phase. This eccentric component is not present in the jump from a fixed position (development of high values of ground reaction force demands certain amount of time and path). The consequence of the above stated is a higher acceleration during take-off, also meaning a higher jump in the CMJ test, in relation to the SJ test. The inefficient transition from the eccentric to the concentric muscle action, as well as the usage of the preparatory movements even in the static position test (SJ) might have been the reasons of the lower difference of the SJ and CMJ tests in young volleyball players. Harman et al. (1990) indicated the minor preparatory movements which are often unnoticed but can be observed through the minimum forces of ground reaction, somewhat lower than the body mass. It can be assumed that those movements are even more noticeable in young athletes, indicating a need of previous practice of the SJ test. The approach and the arm swing also had a positive influence on the jump height (Lees et al. 2004). This influence is based on the greater number of factors that jointly enable storage of a higher amount of energy during the eccentric phase of the jump, as well as during the first part of the concentric (propulsive) phase. This energy enables greater body acceleration and higher jump in the finishing part of the propulsive phase. The AJ test is very similar to the spike, performed by young volleyball players during training sessions. It is much more demanding in coordination than the previous tests, and a great number of repetitions are necessary so as to master the performance technique of the test. This is probably the most important reason why young volleyball players use the approach and the arm swing much better than the non-volleyball players (the difference of the results in the AJ and CMJ tests was 11 cm in volleyball players and 6 cm in non-volleyball players).

Conclusion

Although the specificity principle should be accepted in sports training, it is also very important to analyze the basic abilities and knowledge of the young athletes. Vertical jumping ability is surely one of the most important motor abilities in volleyball. Therefore, it is very important to find the tests that would have good measuring characteristics in evaluating this ability. The results of this research showed that the SJ, CMJ and AJ tests performed on the Powertimer device fulfill those demands. Those tests can be used not only in observing the development of certain jumping ability in young volleyball players, but also in the process of selection of young boys who never played volleyball. Significantly better results achieved by young volleyball players in all the jumping ability tests indicated their importance in volleyball success. A very low difference in the CMJ test results, in relation to the SJ test, indicated the need of exercises within training sessions which use own body weight and minimum outer weights, and especially plyometric low intensity exercise. These exercises should emphasize the correct performance technique. Future research should even out the number of examinees of the subsamples, and define the group of non-volleyball players more clearly (e.g. consider only boys who practice the same sport or boys who do not practice any sport), with the aim of obtaining more reliable information on the differences between volleyball players and non-volleyball

players in jumping ability tests. Also, it is important to mention that during the AJ test performance the examinees had trouble with the insufficient contact take-off and landing surface. The author assumes that the examinees could not perform maximum approach and take-off. To determine this, the author suggests future research should compare the results obtained via Powertimer device with the results obtained from jumps performed from vertec or wall measuring scale.

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