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Original empirical article

ONE-LEG VS TWO-LEGS VERTICAL JUMPING PERFORMANCE

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Abstract. *One leg vertical jump is designed to assess functional performance of lower extremity in both health and injured athletes, but there is a preoccupation in the literature to use vertical two-legs jump as measures of leg power, for the purpose of athlete assessment, performance monitoring, talent identification and in some instances prediction of readiness for training or recovery from rehabilitation. The main aim of this research was to quantify and compare the variables of manifested explosive strength, determined by different protocols of Countermovement Jump (CMJ), i.e., to determine lower extremities difference in relation to explosive strength. The sample of subjects consisted of 19 healthy, male students of the Faculty of sport and physical education from Niš, engaged in different sport activities, age 23.16±1.26 years, body height 181.37±6.51 cm and body weight 81.74±8.37 kg (Mean±Std.Dev). Subjects performed five Countermovement Jumps (CMJ), by using three different protocols of maximum vertical displacement: 1) with a left take off leg; 2) with a right take off leg; 3) with both take off legs. Wireless accelerometer «Myotest» (Sion, Switzerland), measured following variables of CMJ: Height (expressed in cm); Power (expressed in W/kg); Force (expressed in N/kg) and Velocity (expressed in cm/s). The results of descriptive statistics showed that the highest values among all variables were obtained after the CMJ protocol performed with two legs. The results of ANOVA test for repeated measurements did not show statistically significant differences between analyzed variables in CMJ with left leg protocol and CMJ with right leg protocol. However, the values obtained after the CMJ protocol with two-legs were significantly higher, in relation to both one-leg jump protocols. Derived data on the muscles' explosive strength of subjects, may help them in improving their physical abilities. Obtained results can also encourage physicians and their*

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patients (e.g. injured athletes), to apply one-leg vertical jumping in rehabilitation process, i.e., to estimate necessary explosive strength of injured lower extremity, by assessing the healthy one and achieve the regular and balanced body look..

Key words: *Explosive strength, vertical jumping, CMJ one leg-two legs protocols, difference*

INTRODUCTION

The only valid and objective way of assessing muscle strenght is measurement with a dynamometer (Bubanj, S. et al., 2010). The explosive strenght, represents the ability, which allows to an athlete a maximum acceleration of his body, toward to an object or a partner. It is particularly important in the athletic throwing, high jump, long jump and sprint. The amount of manifested explosive strenght depends on the percentage and composition of the activated motor units in the corresponding muscle group (Bubanj, R., Branković, M., 1997).Vertical jumps, hops, and/or bounding movements are often used to increase explosiveness and strenght of the lower extremities (Ebben, 2005; McNeely, 2005). In healthy subjects, functional tests can be used to detect abnormal limb symmetry or weakness (Ostenberg et al., 1998). In previous researches conducted by Challis (1998); Vint & Hinrichs (1996), subjects acheived less than twice the jump height in two-legs jump, compared to one-leg jump. Henry and Smith (1961), explained this phenomenon, known as bilateral force deficit, with the maximum voluntary force produced by the subject, which is less when the muscles act simultaneously with the homologous muscles in the contralateral lower extremity, compared to situation in which the muscles of one leg act alone. Author Van Dien et al. (2003), explained bilateral deficit found in isometric and isokinetic tasks, with a reduced neural drive to the muscles of the subject's lower extremities. Author Bobbert (2005), explained bilateral deficit with a reduced active state of the musles in the equilibrium initial position. Namely, in two-legs jump, body weght is distributed over both legs, i.e., muscles are initially further away from their maximale active state, compared to the one leg jump. One leg vertical jump is designed to assesss functional performance of lower extremity in both health and injured athletes, but there is a preoccupation in the literature to use vertical two-legs jump as measures of leg power, for the purpose of athlete assessment, performance monitoring, talent identification and in some instances prediction of readiness for training or recovery from rehabilitation (Russell et al., 2006; Cornwell et al., 2002; Knudson et al., 2001; Arteaga et al., 2000). Thus, there is a need to study to which extent exercises involving two-foot take off jumps affect the efficiency of single foot take off jumps (Milić et al., 2008).

The main aim of this research was to quantify and compare the variables of manifested exsplosive strenght, determined by different protocols of Countermovement Jump (CMJ), i.e., to determine lower extremities difference in relation to explosive strenght.

METHODS

The sample of subjects consisted of 19 healthy, male students of the Faculty of sport and physical education from Niš, engaged in different sport activities, age 23.16±1.26 years, body height 181.37±6.51 cm and body weight 81.74±8.37 kg (Mean±Std.Dev). Subjects were informed about the terms of the research, conducted in accordance with the

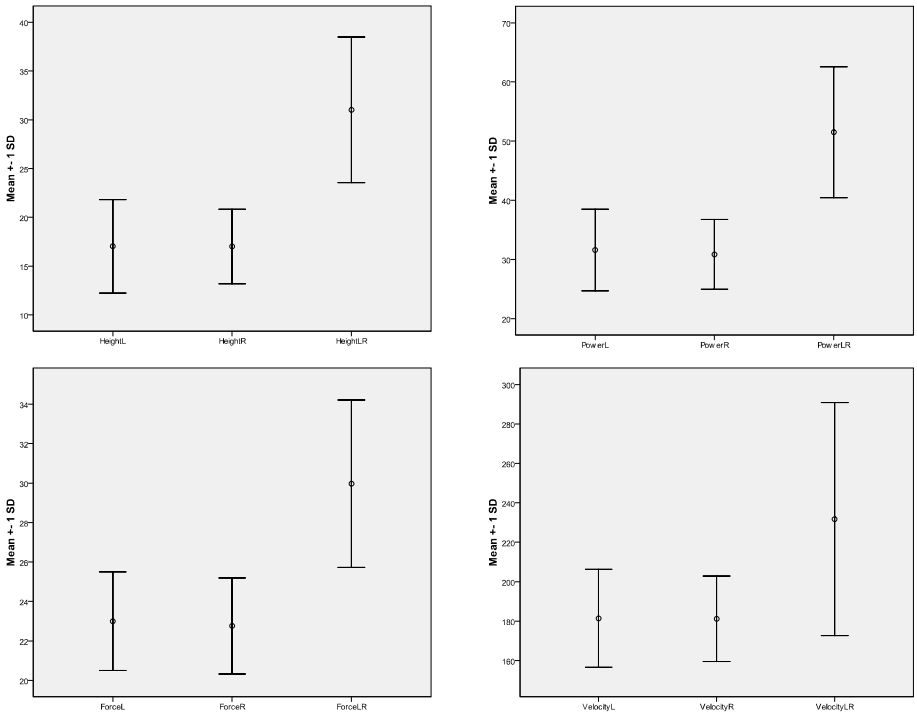
Helsinki Declaration, and they gave a written consent for their volonteerly participation. At the measurement, subjects primarily applied the warming protocol which included 800m of smooth run, 4x30m of skip ahead, 4x30m of lateral skip and 4x30m of skip back, and after, they were asked to perform five vertical jumps (CMJ), with their hands placed on their hips in order to minimaze arms' contribution to leg extensors assessing. CMJ were measured by a wireless accelerometer «Myotest» (Sion, Switzerland), positioned safely on the belt, which subjects carried around their lower trunk. Mentioned device tested four different variables that are important determinants of explosive strenght performance: Height (expressed in cm); Power (expressed in W/kg); Force (expressed in N/kg) and Velocity (expressed in cm/s). Subjects were instructed to wait for the audio signal of the device «Myotest», and perform three different protocols of maximum vertical displacement: 1) with a left take off leg; 2) with a right take off leg; 3) with both take off legs. CMJ protocols comprehended following technique: from the initial position, ie., normal standing position (on left leg, on right leg and on both legs) and the hands placed on their hips, through the flexion in the knee joints up to 90º, after the audio signal of the device, the subjects performed the maximum vertical take-off, and landed with affable flexion (up to 110º) in the knee joints and finally, went back into a starting standing position, while waiting for the new sound signal, when the specified jump technique was repeated. For data statistical analysis and interpretation of the results, software “SPSS version 13” was used. In order to show centrality and spread of results in subjects, Descriptive statistics was used. The Height, Power, Force and Velocity at each protocol were compared by using a one-way analysis of variance (ANOVA). The criterion for establishing statistical significance was $P < 0.05$.

RESULTS

Table 1. Descriptive Statistics of examined variables in three different protocols of CMJ.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
HeightL (in cm)	19	10	28.00	17.03	4.79
HeightR (in cm)	19	9.00	26.30	17.02	3.82
HeightLR (in cm)	19	11.50	47.80	31.01	7.47
PowerL (in W/kg)	19	22.20	48.90	31.61	6.91
PowerR (in W/kg)	19	19.40	45.30	30.85	5.90
PowerLR (in W/kg)	19	24.90	73.60	51.51	11.05
ForceL (in N/kg)	19	18.60	28.10	23.00	2.50
ForceR (in N/kg)	19	19.20	29.20	22.76	2.44
ForceLR (in N/kg)	19	21.20	37.10	29.97	4.24
VelocityL (in cm/s)	19	140.00	234.00	181.42	24.82
VelocityR (in cm/s)	19	127.00	227.00	181.16	21.68
VelocityLR (in cm/s)	19	26.00	306.00	231.74	59.11
Valid N (listwise)	19				



Graph 1. Mean values and Std. deviations of examined variables Height (in cm), Power (in W/kg), Force (in N/kg) and Velocity (in cm/s)

The results of descriptive statistics (table and graphs), showed that the highest values among all variables were obtained after the CMJ protocol performed with two legs.

By using Kolmogorov Smirnov Test it was checked whether the data distribution was normal, in aim of adequate application of ANOVA test or Friedman' test.

Table 2. The results of Kolmogorov-Smirnov Test.

One-Sample Kolmogorov-Smirnov Test

		Height L	Power L	Force L	Velocity L	Height R	Power R	Force R	Velocity R	Height LR	Power LR	Force LR	Velocity LR
N		19	19	19	19	19	19	19	19	19	19	19	19
Normal Parameters[a,,b]	Mean	17.03	31.61	23.00	181.42	17.02	30.85	22.76	181.16	31.01	51.51	29.97	231.74
	Std. Dev.	4.79	6.91	2.50	24.82	3.82	5.90	2.44	21.68	7.47	11.05	4.24	59.11
Most Extreme Differences	Absolute	.21	.16	.12	.16	.16	.12	.11	.13	.14	.13	.11	.26
	Positive	.21	.16	.12	.16	.16	.12	.11	.13	.14	.12	.06	.19
	Negative	-.12	-.09	-.106	-.10	-.11	-.09	-.08	-.130	-.13	-.125	-.11	-.26
Kolmogorov-Smirnov Z		.90	.71	.52	.71	.69	.53	.49	.57	.62	.54	.48	1.15
Asymp. Sig. (2-tailed)		.40	.70	.95	.69	.73	.94	.97	.90	.84	.93	.98	.14

a. Test distribution is normal.
b. Calculated from data.

In regard to the fact, that all variables had a normal distribution, it was allowed to apply the ANOVA test for repeated measures.

Table 3. The results of ANOVA test for repeated measurements.

	Paired Differences			t	df	Sig.
	Mean	Std. Deviation	Std. Error Mean			(2-tailed)
HeightL - HeightR	.01	3.24	.74	.02	18	.99
HeightL - HeightLR	-13.98	5.74	1.32	-10.61	18	.00
HeightR - HeightLR	-13.99	5.23	1.20	-11.67	18	.00
PowerL - PowerR	.76	5.09	1.17	.65	18	.53
PowerL - PowerLR	-19.91	8.45	1.94	-10.26	18	.00
PowerR - PowerLR	-20.66	8.00	1.83	-11.27	18	.00
ForceL - ForceR	.24	2.39	.55	.43	18	.67
ForceL - ForceLR	-6.97	3.93	.90	-7.74	18	.00
ForceR - ForceLR	-7.21	3.32	.76	-9.46	18	.00
VelocityL - VelocityR	.26	16.88	3.87	.07	18	.95
VelocityL - VelocityLR	-50.32	52.35	12.01	-4.19	18	.00
VelocityR - VelocityLR	-50.58	55.67	12.77	-3.96	18	.00

The results of ANOVA test for repeated measurements did not show statistically significant differences between analyzed variables in CMJ with left leg protocol and CMJ with right leg protocol. However, the values obtained after the CMJ protocol with two-legs were significantly higher, in relation to both one-leg jump protocols.

DISCUSSION

Concerning some of the previous researches, it is not clear whether the jump height was defined relative to the height of the whole body center of gravity (CG) in normal standing position or whether to the height of CG at take off. The device Myotest calculates jump height from flight time (Myotest, n.d.). The results of actual research are not in accordance with the results of research conducted by Maarten et al. (2006). Namely, mentioned authors concluded that the height, the work and the ground reaction force were smaller over most of the range of the motion in two-legs jump, compared to one-leg jump. Concerning the velocity of the center of mass, it was was greater over most of the range of motion in the two-legs jump, compared to the one-leg jump. Further, the results of researche conducted by Challis (1998), indicated that jump height was smaller in two-legs jumps in comparision to one-leg jumps. On the other hand, according to Vint & Hinrich (1996), one-leg and two-legs vertical jumping protocols achieved the same reach height, although the techniques applied to achieve mentioned results were notably different. Beter performance during two-legs CMJ protocol, can be atributed to the greater applied force at the end of the streching phase, compared to one-leg CMJ protocol. It is known that in vertical jumping extensor musles can operate most effectively by concentric (ballistic) contraction from the position of half-squat (90º angle

in knee joint). Reason of producing less explosive force in one-leg CMJ protocol, compared to two-legs CMJ protocol, can be atributed to unstable equilibrium position and the incapacity of subjects to take a favorable position in half squat (90º). In such condition subjects abbreviated pathway, necessary to produce greater take off impuls.

CONCLUSION

Derived data on the muscles' explosive strenght of subjects, may help them in improving their physical abilities. Obtained results can also encourage physicians and their patients (e.g. injured athletes), to apply one-leg vertical jumping in rehabilitation process, i.e., to estimate necessery explosive strenght of injured lower extremity, by assesing the helthy one and achieve the regular and balanced body look.

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RAZLIKE U VERTIKALNOM SKOKU IZVEDENOM ODSKOKOM SA JEDNE I SA DVE NOGE

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Vertikalni skok izveden jednom nogom se koristi u cilju procene ekplozivne snage donjih ekstremiteta i zdravih i povređenih sportista, mada se u tu svrhu u literaturi uglavnom preporučuje sunožni vertikalni skok u cilju monitoringa sportiste, tj., njegovog dostignuća, identifikacije talenata, procene spremnosti sportiste da se uključi u određeni trenažni proces i u periodu rehabilitacije. Osnovni cilj ovog istraživanja bio je da se kvantifikuju i uporede varijable ispoljene eksplozivne snage, određene primenom različitih protokola vertikalnog skoka, tzv. Countermovement Jump (CMJ), odnosno da se utvrdi razlika u eksplozivnoj snazi donjih ekstremiteta. Uzorak ispitanika se sastojao od 19 zdravih studenata Fakulteta sporta i fizičkog vaspitanja iz Niša, koji upražnjavaju različite sportske aktivnosti, muškog pola, starosti 23,16 ± 1,26 godina, telesne visine 181,37 ± 6,51 cm i telesne težine 81,74 ± 8,37 kg (Mean±Std.Dev). Ispitanici su izveli pet CMJ skokova, koristeći tri različita protokola: 1) sa levom odskočnom nogom; 2) sa desnom odskočnom nogom; 3) odskokom sa obe noge. Upotrebom bežičnog akcelerometra «Myotest» (Sion, Švajcarska), utvrđene su vrednosti sledećih varijabli CMJ: Height (visine izražene u cm), Power (snage izražene u W/kg), Force (sile izražene u N/kg) i Velocity (brzine izražene u cm/s). Rezultati deskriptivne statistike pokazali su da su najveće vrednosti svih varijabli dobijene primenom CMJ protokola odskoka sa obe noge. Rezultati ANOVA-e za ponovljena merenja, su pokazali da ne postoje statistički značajne razlike između varijabli CMJ protokola sa levom nogom i CMJ protokola sa desnom nogom. Međutim, vrednosti varijabli dobijenih CMJ protokolom sa obe noge bile su značajno veće u odnosu na oba CMJ protokola odskoka sa jednom nogom. Dobijeni podaci mogu biti od pomoći ispitanicima u poboljšanju njihove eksplozivne snage mišića. Rezultati mogu da ohrabre lekare i pacijente (povređene sportiste) da primenjuju vertikalne skokove sa jednom nogom u procesu rehabilitacije, tj., da se testiranjem i analizom rezultata zdrave noge, proceni neophodna eksplozivna snaga povređene noge, kako bi se u krajnjem dobio pravilan i uravnotežen izgled tela.

Ključne reči: *Eksplozivna snaga, vertikalni skok, CMJ protokoli, razlika*