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Relationship between Muscle Strength of Knee Stabilizers and Quality of Vertical Jump Performance in Physically Active Female Population

Izet Bajramovic[1], Ensar Abazovic[1], Denis Causevic[1], Ivor Doder[1], Haris Alic[1], Erol Kovacevic[1], Nedim Babic[1] and Slavenko Likic[1]

[1]University of Sarajevo, Faculty of Sport and Physical Education, Sarajevo, Bosnia and Herzegovina

Abstract

High relationships between muscle strength and various forms of jumps are usually based on the research samples of professional athletes or students of sports and physical education. However such studies are less known in the case of recreational women. This study aimed to determine the relationship between isokinetic parameters of knee joint muscle strength with the efficiency of performing vertical jumps. The sample represents a group of 16 healthy and physically active women (age=31.04±3.71; height 168.13±8.34; weight 59.80±9.80). Knee extensors and flexors were evaluated by using an isokinetic dynamometer, while the two-foot vertical jump performance was measured using the Opto Jump System. Pearson's correlation coefficient was used to determine correlation magnitude ($p<.05$). The obtained results indicated high correlations of the knee extension peak torque dominant leg (KEPT D), knee extension peak torque non-dominant leg (KEPT ND) and knee flexion peak torque non-dominant leg (KFPT ND) with counter movement jump free arms (CMJFA) ($r=.525$; $r=.511$; $r=.594$; $p<.05$). High correlations was also indicated between KFPT ND with counter movement jump (CMJ) ($r=.514$; $p<.05$). Given that these are recreational women, we can assume that the countermovement free arm jump type was the most natural form of expressing their explosive potential. It is certainly important that future studies further examine the relationships between muscle strength and performance of primary and specific motor tasks in recreational women.

Keywords: *knee joint, peak torque, jumps, recreational women*

Introduction

As a type of motor ability, the explosive strength represents one of the determinants of success in all the activities which demand the use of great muscle force in the shortest period (Metikoš et al., 1989). Jumping is a complex human movement that requires complex motor cooramedination between the upper and lower body segments. In particular, the propulsive action of the lower limbs during a vertical jump has been considered particularly suited for evaluating explosive characteristics of elite athletes and sedentary individuals (Genuario & Dolgener, 1980; Bosco & Komi, 1980; Markovic, Dizdar, Jukic, & Cardinale, 2004). Also, most complex sports movements contain specific movements similar to those used in everyday life (Bjelica, 2013).

The results of various jump tests show a high correlation and are interpreted as a factor of explosive strength of the lower extremities (Bjelica & Fratrić, 2011). The relation between peak torque and maximum jump has been the subject of several previous research (Bosco, Luhtanen, & Komi, 1983; Binet, Lehance, Vandenbroek, Bury, & Croisier, 2005; Almuzaini & Fleck, 2008; Anderson et al., 1991; Kovačević, Abazović, Bradić, & Vrcić, 2012). However, such research has

Correspondence:

S. Likic
University of Sarajevo, Faculty of Sport and Physical Education, Patriotske lige 41, 71000 Sarajevo, Bosnia and Herzegovina
E-mail: slavenko.likic@fasto.unsa.ba

been conducted on samples of elite athletes and/or students of sports and physical education. Also, no studies have been found to determine the relations between peak torque and vertical jump height in the recreational population. This difference is essential to emphasize since the first listed samples have good movement pattern, and therefore, this correlation is primarily important in the recovery period. In the recreational population, who often have not adopted good and sometimes even correct movement structures, this correlation brings even more significant benefit.

Although it can be assumed that there is a connection between maximum strength and vertical jump height in recreational individuals, the same has not been investigated so far. Therefore, the question arises whether there is a lower correlation between these parameters in recreational individuals, and if so, what is its basis. Accordingly, this research aimed to determine the relationship between the peak torque, measured by an isokinetic dynamometer, and the height of the vertical jump.

Methods

Participants

The sample consisted of women (n=16), middle-aged (age 31.04±3.71; height 168.13±8.34; weight 59.80±9.80), with no lower extremity injuries during the last two years and with active participation in group recreational programs for at least the past year.

Variables and measurement protocol

Isokinetic variables (Biodex System): Knee extension peak torque of dominant leg (KEPT D) (Nm), Knee extension peak torque of non-dominant leg (KEPT ND) (Nm), Knee flexion peak torque of dominant leg (KFPT D) (Nm), and Knee flexion peak torque of non-dominant leg (KFPT ND) (Nm), Hamstring/quadriceps unilateral ratio of dominant leg (H/Q D) (%) and Hamstring/quadriceps unilateral ratio of non-dominant leg H/Q ND (%). CON/CON 60°/s isokinetic protocol was implemented according to Abazovic et al. (2015). Variables for estimating explosive strength - jump type: Squat jump (SJ) (cm), Countermovement jump free arms (CMJFA) (cm) and Countermovement jump (CMJ) (cm). A standardized warm-up procedure was performed (10-minute of ergometer-cycling followed by 7 minutes of dynamic stretching). Dominant and non-dominant leg were determined based on the statement of the respondents. Each subject was tested through nine jumps: three attempts of SJ, CMJFA and CMJ. The pause between the same jumps lasted 20 seconds, while the pause between different jumps lasted 60 seconds. The highest jump attempt was taken for further analysis.

Statistical analysis of the results

The results were analyzed in the IBM-SPSS 23 statistical program. Descriptive parameters of all variables were calculated: minimum and maximum value, arithmetic mean (Mean), standard deviation (± SD), skewness and kurtosis. The correlation of the variables was calculated using the Pearson correlation coefficient (r). Statistical significance was set at the conventional 95%. The magnitude of the correlation was interpreted as follows: small (r=0,10 to 0,29); moderate (r=0,30 to 0,49); high (r=0,50 to 0,69), perfect (r=1) (Hopkins, 2002).

Results

Subjects achieved better results in all isokinetic variables with their dominant leg (Table 1). The variable Elevation CMJFA indicates a slightly more pronounced grouping of most results to the left of the arithmetic mean. Other skewness results have fair values. The variables KEPT D, KEPT ND, and KFPT D are closest to the ideal distribution of results. A slightly more pronounced negative value of kurtosis in the variables KEPT D and KFPT D indicates platykurtic curve, which means that part of the result is positioned on the tails of the curve. The variable Elevation CMJ has a leptokurtic roundness of the curve, which indicates the positioning of the results near the center of the distribution. The one-sided strength ratio between legs flexors and extensors, based on the values of the arithmetic means, points to a slightly worse ratio in the case of both H/Q variables. The dominant leg (49.57%) has somewhat more pronounced muscle imbalance than the non-dominant leg (47.55%). The optimal value of the ratio of the front and back of the thigh is 61% (Biodex normative goals).

Table 1. Descriptive parameters of isokinetic strength of legs and explosive strength of jump type

	Min	Max	Mean±SD	Skewness	Kurtosis
KEPT D	116.4	216.6	164.36±33.37	.05	-1.58
KEPT ND	113.1	209.1	155.97±30.28	.17	-1.00
KFPT D	56.5	112.0	81.35±18.70	.10	-1.54
KFPT ND	42.1	96.2	74.20±16.72	-.44	-.92
H/Q D	38.3	60.1	49.58±5.14	-.24	.85
H/Q ND	34.6	56.3	47.56±6.17	-.97	.54
SJ	17.5	31.8	23.34±3.65	.73	.40
CMJFA	21.7	36.8	26.38±4.16	1.19	1.19
CMJ	16.2	31.9	23.50±4.16	.41	-.04

Legend: D: dominant; ND: non dominant; KE: knee extension; KF: knee flexion; PT: peak torque; H/Q: hamstring/quadriceps ratio; SJ: squat jump; CMJFA: countermovement jump free arms; CMJ: countermovement jump

High positive direction correlations (Table 2) were found between the variables KEPT D and CMJFA (r=.525; p<.05); KEPT ND and CMJFA (r=.511; p<.05); KFPT ND and CMJFA (r=.594; p<.05); KFPT ND and CMJ (r=.514; p<.05). Other treated variables do not correlate with each other (p>.05).

Table 2. Relations between isokinetic leg strength and jump-type explosive power

Variables	SJ	CMJFA	CMJ
KEPT D	.393	.525*	.472
KEPT ND	.348	.511*	.460
KFPT D	.308	.424	.413
KFPT ND	.410	.594*	.514*
H/Q D	-.082	-.029	.015
H/Q ND	.188	.291	.222

Legend: * - Correlation is significant at the 0.05 level

Discussion

Considering the research aims to determine the relationship between the peak torque and vertical jump height, it is important to point out the following observations.

Table 2 indicates that the squat jump height did not have a statistically significant correlation with the peak torque of the knee extensors and flexors. On the other hand, CMJ and CMJFA indicated statistically significant correlations with isokinetic parameters. Although both CMJs are related to isokinetic power parameters, it is still noticeable that the free-hand jump result indicates the highest correlation with isokinetic power parameters. Therefore, it can be assumed that this sample did not maximally trigger the active musculature during the other two vertical jumps.

Although the reasons for the weak correlation with SJ and the existence of significant correlation with both forms of CMJ are explained below, it is worth mentioning that the magnitudes of the correlation coefficient differ from some previous studies. Thus, Bosco et al. (1983), Binet et al. (2005), and Tsiokanos, Kellis, Jamurtas and Kellis (2002) recorded correlation coefficients ($r>0.6$; $p<0.05$), but it is important to note that in these studies the samples were composed of active athletes. On the other hand, in the study by Blackburn and Morrisey (1998), in the case of physically inactive women who did not have lower extremity injuries, no significant correlations were found at all ($r=0.097$; $p>0.05$). Wilson & Murphy (1995) recorded most similar results to this research and the most similar sample of physically active individuals.

Although CMJ and CMJFA do not differ significantly from SJ, the main difference is reflected in the volume of instructions that should be given for the first two variables, and which, although they do not look like that, can represent a significant modification of previously adopted movements in the case of recreational individuals. Due to weakness of the m. gluteus medius (Semciw, Pizzari, Murley, & Green, 2013) a squat jump can cause unwanted valgus or "knee failure" medially in untrained or poorly trained individuals during the stabilization phase (or semi-squat retention), which significantly and acutely increases the level of stress that also occurs typically in the knee joint (Joseph et al., 2008). Also, during CMJ the muscles are actively "pre-stretched", absorb force and use the elastic energy stored in muscles and tendons (Komi & Bosco, 1978). This indicates that due to an eccentric-concentric cycle, the total work performed during CMJ is higher than in SJ (Komi & Bosco, 1978).

The performance of motor tasks that have two or more instructions, and that require the simultaneous performance of two and/or more tasks, and which are commonly used to assess the effect of the second task on the performance of the first (Huang & Mercer, 2001) has been investigated several times. Most authors are consistent in stating that trained individuals perform significantly better results when performing complex tasks than untrained ones and even when their results do not differ significantly in some basic motor tasks (Abernethy, 1993; Beilock, Carr, MacMahon, & Starkes, 2002; Gray, 2004).

Following the above, it can be concluded that there is a high correlation between the peak torque and maximum jump height in recreational women. With the complexity of the motor task, the intensity of correlation becomes lower. At the same time, in SJ there is no correlation between these values. Furthermore, the results indicated that it is necessary to determine how the complexity of performing additional motor tasks may affect the level of performance of the primary motor task. In addition to the perceptual and motor performances, investigating athletes' neurophysiological background would be sufficient to make a connection between motor and neural mechanisms (Gardasevic, Akpinar, Popovic, & Bjelica, 2019).

This study showed a strong positive correlation between knee extensors PT and CMJFA height in recreationally trained females. Furthermore, the absence of correlation between SJ, CMJ, and knee extension PT might be due to the low movement mechanics. Given that these are physically active women, we can assume that their countermovement free arm jump type was the most natural form of expressing their explosive potential.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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