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RELATIONSHIP BETWEEN ISOKINETIC DYNAMOMETRY AND TENSIOMYOGRAPHY IN INDIVIDUALS WITH DIFFERENT MUSCLE POWER MANIFESTATION

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Abstract The aim of this study was to investigate the correlations between isokinetic dynamometry and tensiomyography (TMG) in individuals with different levels of muscle power manifestation. The sample consisted of 85 male participants divided in three groups according to their levels of muscle power manifestation: low (LMP), average (AMP), and high (HMP). Isokinetic dynamometry was used to measure average muscle power of knee joint extensor and flexor muscles of the knee joint of the dominant leg at angular velocities of 60 º/s and 180 º/s, while tensiomyography measured maximal displacement (Dm) and contraction time (Tc) of the main knee joint extensor and flexor muscles: rectus femoris and biceps femoris. Correlation analysis revealed some significant correlations between the parameters obtained by isokinetic dynamometry and tensiomyography, the highest being in the LMP group ($r = -0.461$, $p = 0.021$, on average), and the lowest in the HMP group ($r = -0.564$, $p = 0.045$). These findings indicate that the correlation between the results obtained by these two methods weakens with the increase in muscle power manifestation, and that this increase depends to an extent on muscle contraction velocity and muscle stiffness, while high muscle power manifestation is influenced by other factors.

Key words: isokinetic dynamometry, tensiomyography, muscle power, maximal displacement, contraction time

INTRODUCTION

Performing the most complex and intense soccer movements are under the influence of adequate and quality training process. Players develop the foundation of abilities, knowledge and skills that enable them to perform almost perfect kicks, receive the ball while sprinting, kick the ball with a precision, sprint aggressively and change direction many times.

Sports diagnostics is an important part of modern sport [9]. The assessment of physical abilities, morphological characteristics and other parameters of importance for physical activity has been used in sport, physical education, recreation and rehabilitation for decades. It follows that athletes in different sports constantly try to improve their skills and performance with the use of state-of-the-art diagnostic technology [6].

One of the main subjects of sports diagnostics and sports science is the assessment of muscle contractile properties. Of particular interest are the contractile properties of leg muscles, such as muscle strength, power, and speed of contraction. As these muscle properties play an important role in everyday activities as well as in sports [1], numerous methods have been developed for their assessment.

Tensiomyography (TMG) and isokinetic dynamometry are methods often used in sports and medicine, as well as in research related to contractile properties of muscles. While isokinetic dynamometry is used to assess voluntary muscle properties such as strength, power, and work [2,8,12,13], TMG is a relatively novel method used in the assessment of involuntary contractile and mechanical properties such as muscle stiffness, muscle contraction speed, or muscle responsiveness [11,10].

So far, several studies have examined the correspondence between these methods [18,19,20,21]. These studies investigated the relationship between the results of isokinetic dynamometry and tensiomyography in people with different levels of physical activity, that is, physically inactive and active non-athletes, and athletes from three different sport groups (strength-and-power, endurance-, and team-sport athletes). However, these studies did not take into consideration muscle strength or muscle power manifestation in participants.

Thus, the aim of this study was to investigate the relationships between the results obtained by isokinetic dynamometry and TMG in individuals with different muscle power manifestations. It was hypothesized that there was a significant correlation between these methods in individuals with different muscle power manifestations, that is, that the level of muscle power manifestation would influence the correspondence between these methods. The results of this study could contribute to the development of sports diagnostics and further the training processes in sport, injury prevention, and physical rehabilitation.

METHODS AND MATERIALS

PARTICIPANTS

The study sample consisted of 85 males (age = 24.3 ± 3.4 years; body height = 178.4 ± 5.8 cm; body weight = 78.4 ± 8.1 kg, on average). The subjects were clustered into three groups according to their level of muscle power manifestation: low-level – LMP (24), average-level – AMP (48), and high-level muscle power manifestation – HMP (13). The subjects' physical activity status was different (physically inactive non-athletes, physically active non-athletes, and athletes). All participants were familiar with the study aim and procedures, and they voluntarily agreed to participate in the study. All testing was conducted in accordance with the Declaration of Helsinki and the rules of the Ethics Committee of Faculty of Sport and Physical Education, University of Belgrade, Serbia (IRB: 484-2).

The measuring instruments used in the study were the Kin-Com AP125 isokinetic dynamometer (KinCom, Kinetic Communicator; Chattecx Corp., Chattanooga, TN, USA) and tensiomyography measuring device (TMG-BMC Ltd, Ljubljana). The isokinetic dynamometer was used to measure average muscle power (P_{avg}) of knee joint extensor (Q) and flexor (H) muscles of the dominant leg at angular velocities of 60 º/s (60) and 180 º/s (180), while TMG measured the parameters of maximal displacement (Dm) and contraction time (Tc) of the main knee joint extensor and flexor muscles of the dominant leg: rectus femoris (RF) and biceps femoris (BF). All testing was conducted by the same experienced individuals in the methodology-research laboratory of University of Belgrade Faculty of Sport and Physical Education, according to the procedures described in previous studies [16,17,18,19,20,21] and the manufacturer's recommendation (Figures 1 and 2).

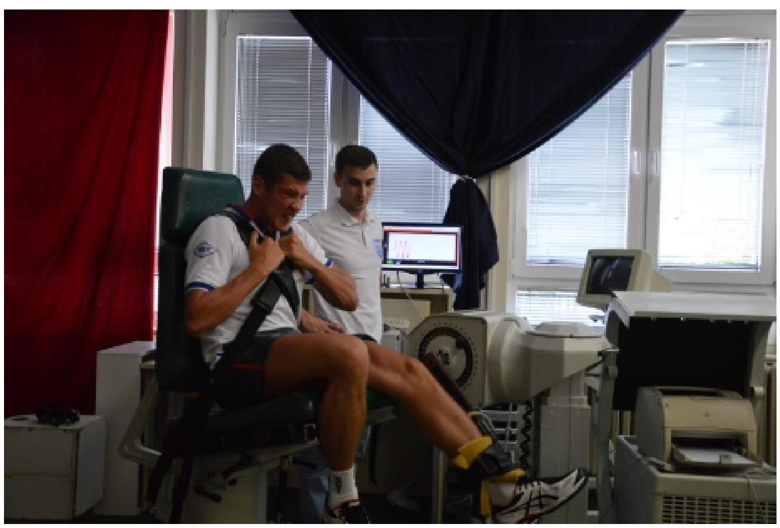

Figure 1. Measurements on the isokinetic dynamometer

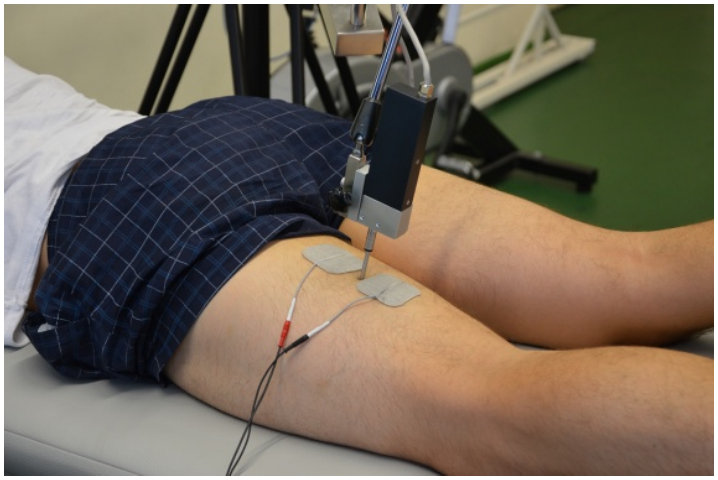

Figure 2. Measurements on the TMG device

STATISTICAL ANALYSIS

Descriptive statistics were used in the research (Mean, SD) and the Pearson correlation coefficient was calculated. Classes of participants were defined according to the criterion of power manifestation levels using cluster analysis. The level of statistical significance was 95 % with $p < 0.05$ [5]. All statistical procedures were performed in the IBM SPSS19.

RESULTS

Tables 1 and 2 show the descriptive values of the isokinetic and TMG parameters in individuals with different levels of muscle power manifestation. It can be noticed that the knee joint extensor muscles had higher values of average muscle power than the knee joint flexor muscles and that these values were higher when muscle power was measured at higher velocities (all groups), which was expected. With respect to the TMG parameters, it can be noticed that Tc values were lower in the RF muscle, while Dm values were lower in the BF muscle (all groups). Also, individuals from the HMP group had the lowest values of Tc and Dm (in both RF and BF). Interestingly, homogenity of results is much lower in TMG (cV = 26.8±7.03 %, on average) than isokinetic parameters (cV = 13.8±3.2 %, on average).

Table 1. Descriptive values (Mean±SD*(cV)*) of isokinetic dynamometry parameters

	Q60 (W)	Q180 (W)	H60 (W)	H180 (W)
LMP	132.2±23.8 *(18)*	267±48.1 *(18.01)*	84.6±15.2 *(17.9)*	191.1±33.5 *(17.5)*
AMP	178.8±19.1 *(10.6)*	372.4±35.3 *(9.47)*	113.8±14.9 *(13.09)*	264.4±34 *(12.8)*
HMP	238.8±32.3 *(13.5)*	483.7±53.5 *(11.06)*	141.2±14.8 *(10.4)*	335.8±43.9 *(13.07)*

LMP – low muscle power manifestation, AMP – average muscle power manifestation, HMP – high muscle power manifestation

Table 2. Descriptive values (Mean±SD*(cV)*) of TMG parameters

	TcRF (ms)	TcBF (ms)	DmRF (mm)	DmBF (mm)
LMP	29.7±3.9 *(13.1)*	36.8±10.2 *(27.7)*	6.42±1.95 *(30.3)*	6.25±2.29 *(36.6)*
AMP	31.5±5.6 *(17.7)*	33.8±8.9 *(26.3)*	5.84±1.86 *(31.8)*	5.06±1.77 *(34.9)*
HMP	26.1±5.3 *(20.3)*	31.9±9.2 *(28.8)*	5.44±1.66 *(30.5)*	4.42±1.03 *(23.3)*

LMP – low muscle power manifestation, AMP – average muscle power manifestation, HMP – high muscle power manifestation

Tables 3 and 4 display the correlation statistics, showing the correlations between isokinetic dynamometry and TMG parameters for the knee joint extensor and flexor muscles in individuals with different levels of muscle power manifestation. It can be concluded that there was a statistically significant correlation between all P_{avg} parameters and BF muscle Tc ($r = 0.461$, $p = 0.021$, on average) in the LMP group. Also, significant correlations were found between BF muscle Dm and P_{avg} of knee joint extensor muscles measured at velocities of 60 º/s and 180 º/s ($r = -0.574$, $p = 0.040$; $r = -0.356$, $p = 0.011$, respectively) in the AMP group, and P_{avg} of knee joint flexor muscles measured at the velocity of 180 º/s and BF muscle Dm ($r = -0.564$, $p = 0.045$). There were no significant correlations in the other TMG parameters of the BF muscle, or in any parameters of the RF muscle.

Table 3. Correations between isokinetic dynamometry and TMG parameters of RF muscle

			Q60	Q180	H60	H180
LMP	Tc	r	-0.082	-0.107	-0.314	-0.377
		p	0.696	0.612	0.126	0.064
	Dm	r	-0.109	-0.198	0.079	0.140
		p	0.604	0.343	0.707	0.503
AMP	Tc	r	-0.004	0.031	-0.039	-0.002
		p	0.978	0.832	0.787	0.988
	Dm	r	-0.159	-0.209	0.231	0.045
		p	0.271	0.146	0.107	0.754
HMP	Tc	r	-0.053	0.067	0.339	0.092
		p	0.864	0.829	0.257	0.764
	Dm	r	0.154	0.473	0.504	0.484
		p	0.616	0.103	0.079	0.094

Legend: LMP – low muscle power manifestation, AMP – average muscle power manifestation, HMP – high muscle power manifestation, r – correlation coeficient, p – significance

Table 4. Correations between isokinetic dynamometry and TMG parameters of the BF muscle

			Q60	Q180	H60	H180
LMP	Tc	r	**-0.449**	**-0.489**	**-0.424**	**-0.483**
		p	**0.024**	**0.013**	**0.035**	**0.014**
	Dm	r	-0.142	-0.212	-0.185	-0.194
		p	0.499	0.309	0.375	0.353
AMP	Tc	r	-0.259	-0.272	-0.134	-0.146
		p	0.069	0.056	0.353	0.311
	Dm	r	**-0.574**	**-0.356**	-0.003	0.022
		P	**0.040**	**0.011**	0.982	0.879
HMP	Tc	r	0.181	-0.117	-0.356	-0.259
		p	0.554	0.704	0.233	0.070
	Dm	r	0.046	-0.1	0.505	**-0.564**
		p	0.881	0.746	0.078	**0.045**

Legend: LMP – low muscle power manifestation, AMP – average muscle power manifestation, HMP – high muscle power manifestation, r – correlation coeficient, p – significance

DISCUSSION

This study investigated the correlations between parameters obtained by isokinetic dynamometry and tensiomyography in individuals with different levels of muscle power manifestation. Its results could provide information on the influence of muscle power manifestation on the correspondence between these two methods, indirectly leading to the development of sports diagnostics and thus to the improvements in the training processes in sport, injury prevention, and physical rehabilitation.

The main finding of this study is that some of the parameters of isokinetic dynamometry and TMG correlated significantly (Table 4). There were significant correlations between all P_{avg} parameters and BF muscle Tc in the LMP group, P_{avg} of the knee joint extensor muscles measured at both velocities and BF muscle Dm in the AMP group, and P_{avg} of knee joint flexor muscles measured at the velocity of 180 º/s and BF muscle Dm in the HMP group. These results are in accordance with the previous studies that emphasized some significant correlations between isokinetic dynamometry and TMG parameters [18,19,20,21].

The correlations between P_{avg}, Tc and Dm were negative, which implies that the individuals with higher values of P_{avg} had lower values of Tc and Dm, and vice versa (Table 4). Since the Tc parameter is associated with muscle fibre composition and reflexes the speed of twitch force generation [3,4,10,15], while the Dm parameter is associated with muscle mechanical properties such as muscle stiffness [14,15,22], it can be concluded that individuals with higher muscle power manifestation will have lower values of speed of twitch force generation and muscle stiffness, that is, they will manifest higher muscle contraction speed and stiffer muscles.

Significant correlations between the isokinetic dynamometry and TMG parameters were highest in the LMP group (r = -0.461, p = 0.021, on average), followed by the AMP (r = -0.465, p = 0.025, on average), while they were lowest in the HMP (r = -0.564, p = 0.045) (Table 4). This finding indicates that the correlation between these methods weakens with the increase in muscle power manifestation. More importantly, these results imply that an increase in muscle power manifestation depends on muscle contraction velocity and muscle stiffness to an extent, whereas high muscle power manifestation is dependent on other factors such as muscle mass or architecture. This suggests that similar studies should always take into consideration muscle strength and power manifestation.

Significant correspondence between the two methods was found in the knee joint flexor muscle (BF), while there were no significant correlations in the knee joint extensor muscle (RF). This indicates that the BF muscle was very important in power manifestation of the knee joint muscles (Tables 4 and 5). Also, a higher correlation was found in Tc than in Dm, which could indicate that the speed of twitch force generation had more influence on muscle power manifestation than muscle stiffness (Tables 4 and 5). Finally, a higher correlation between the parameters obtained by the two methods was found when isokinetic muscle power was measured at higher velocities, which could indicate that speed of twitch force generation and muscle stiffness had more significance in fast movements (Table 4). These findings also concur with previous similar studies [18,19,20,21].

CONCLUSIONS

Significant correlations between the parameters obtained using isokinetic dynamometry and tensiomyography were the highest in the LMP group and the lowest in the HMP, which indicates that the correspondence between these methods weakens with the increase of muscle power manifestation. These results could suggest that an increase in muscle power manifestation depends partly on muscle contraction velocity and muscle stiffness, while high muscle power manifestation is influenced by other factors. Therefore, it may be advisable to consider muscle strength and power manifestation in future studies of this type.

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