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ABSTRACT

The aim of this study was two-fold. Firstly we wanted to quantify the relationship of isokinetic muscle strength (IMS) and long jump performance (LJP) in young jumpers, and secondly to compare males and females in IMS. Our measurements in 7 males and 7 females showed that the LJP was correlated with the normalized peak joint moment of the concentric knee extensions and the concentric ankle plantar flexions. A low correlation was observed between the LJP and the eccentric knee extensions. The t-test showed significant gender differences in joint peak moment of concentric knee extensions and in normalized peak joint moment of concentric plantar flexions and eccentric plantar flexions at 120 deg/sec. Although, our findings suggest that IMS is a major contributor to LJP, it is suggested that training intervention should not be based exclusively on isokinetic tests because of the differences in musculoskeletal function between the two movements.

KEY WORDS: *athletics, ballistic movements, isokinetic torque.*

INTRODUCTION

In recent years many researchers have tried to establish relationships between isokinetic muscle strength and performance in competition events (e.g. sprinting performance) (1, 5, 6). Blazeovich and Jenkins (3) determined the associations between hip extensor/hip flexor strength, squat strength and sprint running velocity and found that hip flexor strength variables best predicted running performance. Dowson et al. (5) examined the relationship in elite performers of isokinetic muscle strength across three lower limb joints and sprinting performance and found that the stronger predictor of the sprint performance was the concentric knee extension at 240 deg/sec ($r = -0.688$, $P < 0.01$).

Except sprinting performance dynamic muscle strength is an important component in running long jump performance. The driving forces generated during the touchdown and take-off are closely related to the concentric and eccentric action of various knee and ankle muscles. During the last two decades the long jump has received considerable attention in the literature. The main purpose of most papers has been to establish relationships between various parameters of the jump, e.g. approach velocity or takeoff angle, and performance, i.e. long jump length (7, 8, 10). However, to our knowledge, no attempt has so far been made to assess the relationship between long jump performance and isokinetic muscle strength. Hence the main purpose of this study was to examine the relationship between isokinetic muscle strength and running long jump performance in young athletes. The afore-mentioned relationships have been examined at young male and female athletes to determine whether the associations are impacted by morphological and developmental differences between genders.

METHODS

Participants

Seven male (age 16.3 ± 1.2 yrs; body mass 66.5 ± 5.9 Kg; height 176.7 ± 5.4 cm) and seven female (age 16.1 ± 1.2 yrs; body mass 55.6 ± 4.7 Kg; height 166.3 ± 3.1 cm) high level young jumpers volunteered to participate in this study. Before participating in the study, the participants read and signed a consent form.

Testing procedures

The testing procedures were conducting over two days. The first day the anthropometric and isokinetic testing was performed and the second day the running long jump was evaluated.

Anthropometric Testing. Standing height was measured to the nearest 0.5 cm using a Seca Stadiometer 208, with the subject's shoes off and head at the Frankfort horizontal plane. Body mass was assessed to the nearest 0.5 kg (Seca Beam Balance 710).

Isokinetic Testing. A Cybex Norm (Cybex, Ronkonkama, New York, U.S.A) isokinetic dynamometer was used for the measurement of knee extension and ankle plantar flexion moment.

Knee extension was performed with the subjects in the seated position, with their hands gripping the sides of the dynamometer chair. The participants were stabilized with the belts and hip and thigh straps provided by the dynamometer's manufacturer. Straps were positioned over the right thigh and the hips and the standard 4-point belt was used to prevent any extraneous movement of the trunk. Before each knee extension trial, the most prominent point of the femoral epicondyle on the lateral surface of the knee joint was aligned with the dynamometer axis of rotation. The range of motion for the knee was from 90 deg of knee flexion to full extension (0 deg). Ankle plantar flexion was performed with the participants at prone position and the knee in full extension. Stabilizing straps were placed around the ankle, shank and thigh. The range of movement was 55 deg, from 15 deg of dorsi flexion to 40 deg of plantar flexion.

For each test, three submaximal efforts were performed for familiarization and warm up purposes. Then the participants performed three maximal concentric and eccentric knee extensions at an angular velocity of 60 deg/s and 300 deg/sec and three maximal concentric and eccentric ankle plantar flexions at an angular velocity of 60 deg/s and 120 deg/sec.

Gravitational corrections were also performed to account for the effect of leg and dynamometer arm weight on moment measurements. Moreover, in order to assess the actual knee and ankle knee joint moment, inertial effects were considered using previously reported procedure (9). The maximum isokinetic joint moments produced at each testing condition for each joint test was normalized for body mass in kilograms (were expressed as a ratio Nm/kg) and used for further analysis.

Measures of running long jump performance. Each participant was asked to perform six jumps with maximum effort from a full-length approach. The distance of each jump was measured from the toe of the take off leg to the nearest mark made by the participant in the sand. Sufficient recovery time was allowed among trials and the best trial from each subject was used for further analysis.

Statistics

Pearson correlation coefficients analysis was used to examine the relationship between isokinetic strength and running long jump performance. Thomas and Nelson (12) have indicated that when the coefficient of determination is less than 0.50, the variables should be considered specific and independent of each other. Thus, for this study the threshold values for Pearson product-moment correlation coefficients were <0.7 (low), 0.7-0.9 (moderate), and >0.9 (high). Moreover a t-test for independent samples was conducted to examine for any differences between male and female jumpers. In each statistical analysis the level of significance was set at $P < 0.05$.

RESULTS

The relations between the data examined are shown in Table 1. The Pearson correlation coefficients obtained ranged from 0.112 to 0.82 for the males and -0.065 to 0.81 for the females. The running LJP was significantly correlated only with the normalized peak joint moment that produced during the concentric isokinetic knee extension at 300 deg/sec for both males and females (Table 1). However, when males and females were pooled together into a single group, the LJP was significantly correlated to the moderate level with the normalized peak joint moment produced during the concentric isokinetic knee extensions and the concentric isokinetic ankle planter flexions (Table 1). Moreover a low correlation was observed between the LJP and the isokinetic eccentric knee extensions at 60 and 300 deg/sec when men and women were combined into a single population (Table 1).

Table 1. *Relations between the long jump performance and the peak normalized joint moment (relative to body mass) produced during various isokinetic tests by gender*

Long Jump Performance by gender	Peak normalized joint moment							
	Concentric knee extension		Eccentric knee extension		Concetric ankle plantar flexion		Eccentric ankle plantar flexion	
	60 deg/sec	300 deg/sec	60 deg/sec	300 deg/sec	60 deg/sec	120 deg/sec	60 deg/sec	120 deg/sec
Males	.28	.82*	.39	.63	.57	.51	.38	.11
Females	.57	.81*	.67	.20	.70	.15	.11	-.07*
Total	.78**	.89**	.63*	.44	.76**	.72**	.46	.54*

* $p < .05$, ** $p < .01$.

The t-test for independent samples indicates that there was statistical significant difference between genders in running LJP (Table 2). Moreover statistical significant differences were found between males and females in joint peak moment produced during concentric knee extensions at 60 deg/sec (Nkco60) and 300 deg/sec (Nkco300) and in normalized peak joint moment produced during concentric plantar flexions at 60 deg/sec (Nplco60) and 120 deg/sec (Nplco120) and eccentric plantar flexions at 120 deg/sec (Nplecc120) (Table 2). There was no any statistical difference between gen-

ders in normalized peak joint moment produced during eccentric knee extensions at 60 deg/sec (Nkecc60) and 300 deg/sec (Nkecc300) and during eccentric plantar flexions at 60 deg/sec (Nplecc60) (Table 2).

Table 2. Differences between genders in running long jump performance and in normalized peak joint moment produced during various isokinetic tests

Tests	Males		Females		t (12)
	M	SD	M	SD	
LJP	6.51	0.57	5.03	0.47	5.26***
Nkco60	3.44	0.24	2.82	0.35	3.84**
Nkco300	1.83	0.23	1.42	0.25	3.16**
Nkecc60	4.69	0.69	4.09	0.55	1.80
Nkecc300	3.93	0.61	3.55	0.79	1.00
Nplco60	2.21	0.31	1.86	0.18	2.57*
Nplco120	1.84	0.20	1.35	0.29	3.69**
Nplecc60	2.34	0.27	2.14	0.22	1.45
Nplecc120	2.21	0.30	1.82	0.22	2.78*

Note: LJP = running long jump performance; Nkco60 = normalized peak joint moment during concentric knee extensions at 60 deg/sec; Nkco300 = normalized peak joint moment during concentric knee extensions at 300 deg/sec; Nkecc60 = normalized peak joint moment during eccentric knee extensions at 60 deg/sec; Nkecc300 = normalized peak joint moment during eccentric knee extensions at 300 deg/sec; Nplco60 = normalized peak joint moment during concentric plantar flexions at 60 deg/sec; Nplco120 = normalized peak joint moment during concentric plantar flexions at 120 deg/sec; Nplecc60 = normalized peak joint moment during eccentric plantar flexions at 60 deg/sec; Nplecc120 = normalized peak joint moment during eccentric plantar flexions at 120 deg/sec.

* $p < .05$, ** $p < .01$, *** $p < .001$.

DISCUSSION

Comparison of isokinetic muscle strength between female and male young jumpers

It is known that isokinetic muscle strength plays a significant role in various functional performances (2-5). However it is unknown whether there are gender differences in muscle strength that may explain gender differences in functional performance. The results of the present study indicate that the produced normalized (relative to body mass) peak joint moments during various

isokinetic tests are different between female and male young jumpers. In most cases the male jumpers produced normalized joint moment 1.2 times higher than the normalized joint moment produced by the females. Therefore, the difference in running long jump performance between males and females appears to result of differences in the isokinetic muscle strength.

Relationship between running long jump performance and isokinetic muscle strength

The main purpose of this study was to investigate the ability of the isokinetic muscle strength to assess the running long jump performance. Our findings indicate that when male and female jumpers are examining independently only the produced normalized peak joint moment during isokinetic knee extension at 300 deg/sec is a significant predictor of the long jump performance (Table 1). However, when the males and females examined as a single group the LJP correlated significantly with the normalized joint moment that produced during the concentric and eccentric knee extensions and concentric ankle plantar flexions in all the examined joint angular velocities. The fact that the 79% of the variance of the long jump performance can be explained by the isokinetic muscle strength during concentric knee extension at 300 deg/sec indicates that high angular velocities are more appropriate to assess accurately the running long jump performance.

Our results are in accordance with previous findings from Mann (11) who showed that both eccentric and concentric muscle actions of the knee extensors are important in sprinting. The eccentric action is particularly important during touchdown phase, when high ground vertical reaction forces are exerted. The concentric action is important for generating positive vertical forces during the ground contact phase.

CONCLUSION

In conclusion, the moderate correlations found in the present study between strength of the leg muscle groups and running long jump performance suggest that strength is a major contributor to long jump performance. The low correlation coefficients in some cases reflect the differences in musculoskeletal function between the two movements. Isokinetic tests are open kinetic chain activities, which involve the evaluation of an isolated active muscle group through one leg movement with restrictions of the joint angular velocity. In contrast, running long jump is a closed kinetic chain activity where various muscle groups of both legs are activated, whilst there is transfer of energy between segments, with acceleration and deceleration phases in the movement. Therefore, it is suggested that the effect of training intervention should not be based exclusively on isokinetic tests. Various field functional tests combined with isokinetic dynamometry could be recommended.

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