ISOKINETIC STRENGTH OF LEG FLEXORS AND EXTENSOR IN ELITE HIGH JUMPER

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The purpose of this study was to determine the difference in isokinetic strength of lower limb muscle between elite and advance high jumper. MERAC system was employed to measure the peak torque of hip, knee and ankle extensor and flexors at 60°/sec and 240°/sec testing velocity. There were significant different between groups in isokinetic performance. These differences provide the information for the coach to design muscular strength training protocol for high jumper.

KEYWORDS: high jumper, isokinetic testing, flexor, hip, knee, ankle

INTRODUCTION: The purpose of this study was to examine the isokinetic muscle strength of elite high jump athletes. The high jump is an event that the athlete strives to overcome gravitational force. The muscle strength of the legs is an important component contributing to the successful performance of high jump. Therefore, it is of important theoretical and practical value to evaluate the difference in muscle strength of legs between the different levels of athlete. As a relatively new testing and assessing method of muscle function, the isokinetic muscle strength testing has been widely applied in the practical and theoretical aspects of sport and rehabilitation medicine, as well as sport training. Isokinetic muscle strength testing can provide accurate measurements of the power of the muscle Group of all major joints, as well as provide the data on the strength proportion of flexors/extensors. The accommodated resistance in the isokinetic muscle strength testing means that this type of movement is safe. There is no risk of injury to the athlete. The present study investigated the leg muscle strength of male high jumpers at different levels. Suggestions are presented on how to improve the performance by effectively developing the muscle strength of their legs.

METHODS: Nine male elite high jumpers were recruited as subjects in this study. Three of them were experience jumpers. They have been jumped over 230cm many times. They were assigned to Group A. The other athletes whose best records on average were 216.5cm were assigned to Group B.
MERAC system (U.G.E., Inc. USA) was used to record the data. All subjects are required to perform flexion and extension at a slow, 60°/sec, and fast, 240°/sec, speeds. Both speeds were repeated for 6 times and the highest record was taken.
The parameters of this study were peak torque (PT) of the flexors and extensors of hip, knee and ankle joint in 60°/sec and 240°/sec. As the relative strength is more important for the high jumper, as well as an accurate comparison can be made, the current study expressed PT with N·M/kg weight. All measurements were carried out in pre-competition training period on the subjects with no prior injury and illness.

RESULTS AND DISCUSSION: Table 1 shows the subjects' physical characteristics and their best record. It indicated that there was no significant difference in physical characteristics ($p>0.05$). However, there was significant difference in records of high jump between the subjects in Group A and Group B ($p<0.05$}. The difference between groups in record could be attribute to different training perceived, but this result warrant further investigation.

Table 1 Subjects' Record and Body Shape

	Group A	Group B	p
Record (cm)	231.3±1.2	216.5±3.0	$p<0.05$
Height (cm)	189±2.8	187±4.5	$p>0.05$
Weight (kg)	71±6.4	70±6.1	$p>0.05$
Weight/Height (g/cm)	376±29	374±28	$p>0.05$

As shown in Table 2, the PT of flexors were smaller than that of extensors in hip, knee and ankle for all subjects. As expected, since different joints have different anatomical characteristics, there was significant difference $p<0.01$in F/E between joints. Along with the quicker movement, from 60°/sec to 240°/sec, there were no obvious changes in flexion of hips and ankles' muscles ($p>0.05$) while there was significant difference in knees ($p<0.01$). It indicated that the change of flexors were less than that of the extensors.

Zhang (1995) found that, along with the movement increase, the PT of muscles decline. The present study indicated that the Group A declined 18% and Group B declined 25%, respectively and the difference was statistically significant ($p<0.05$ The performance could be improved by increase the run-up speed and then increase the take-off power. The difference in training level between Group A could explain the difference in declination of muscle.). The high jump is a kind of sport requiring explosive force. Therefore, the focus of this study was on the data of 240°/sec testing in evaluating muscle strength.

Table 2 Peak Torque(PT) in Different Speed Testing (N.M/kg weight)

Group	Joints	Muscles	PT (60°/sec)	F/E	PT (240°/sec)	F/E	Difference(%)
	L Hip	Flexors	2.52±0.3	46%	1.91±0.33	44%	24.2
		Extensors	5.48±0.48		4.39±0.26		19.9
	R Hip	Flexors	2.62±0.45	53%	2.27±0.47	55%	13.3
		Extensors	4.98±0.42		4.14±0.42		16.9
	L knee	Flexors	2.47±0.19	63%	2.34±0.06	84%	5.3
A		Extensors	3.89±0.36		2.79±0.02		28.2
	R knee	Flexors	2.41±0.3	61%	2.29±0.16	81%	4.9
		Extensors	3.95±0.48		2.81±0.32		28.8
	L ankle	Flexors	0.52±0.04	24%	0.41±0.02	23%	21.1
		Extensors	2.21±0.3		1.79±0.26		19.1
	R ankle	Flexors	0.52±0.04	24%	0.40±0.02	23%	23.1
		Extensors	2.21±0.3		1.77±0.29		19.9
	L Hip	Flexors	2.49±0.31	46%	1.78±0.31	43%	28.5
		Extensors	5.52±0.42		4.11±0.17		24.1
	R Hip	Flexors	2.43±0.37	49%	2.02±0.35	50%	16.9
		Extensors	5.01±0.36		4.03±0.27		19.5
	L knee	Flexors	2.48±0.26	64%	2.25±0.11	82%	9.2
B		Extensors	3.87±0.41		2.74±0.12		29.2
	R knee	Flexors	2.42±0.16	62%	2.11+0.18	84%	12.8
		Extensors	3.89±0.35		2.52+0.26		35.2
	L ankle	Flexors	0.51±0.06	23%	0.36+0.07	22%	29.4
		Extensors	2.19±0.32		1.61±0.28		26.4
	R ankle	Flexors	0.48±0.08	23%	0.31±0.09	21%	35.4
		Extensors	2.13±0.28		1.49±0.21		30.0

As testing speed increased from 60°/sec to 240°/sec, the F/E of knee joint muscle declined significant. This indicates that the flexors of knees have good adaptability for fast movement. Zhang (1995) reported that the developing F/E could improve the performance of high jumper and prevent the flexors from injury in fast movement.

As Table 2 shows the difference between the muscles of left and right in knees and ankles at 240°/sec testing was not significant between subjects in Group A ($p>0.05$). However,

significant difference could be found in Group B.
The take-off movements of all subjects were performed by left leg. As expected, the muscle strength of the knee and ankle of swinging legs should weaker than that of the take off legs. However, this phenomenon could only be found in Group B. The muscle strength of knee and ankle were equal between left and right side of Group A.
For all subjects, the P/T of flexors of right hip were stronger than that of the left hip, and the P/T of extensors of left hip were stronger than that of the right hip. It maybe a characteristic of the high jumper. The higher PT of flexors in right hip could be attribute to the intensive swinging leg training. The high PT of extensors in left hip is favorable to spread the hip at take-off. The PT on Group A was higher than that on Group B in the two parameters ($p<0.05$) This result could be regarded as the sign of training level difference.

Table 3 Comparison between the Strength of Left and Right Muscles (240°/sec, N.M/kg weight)

Group	Muscles	Joint	Left	Right	p
A	Flexors	Hip	1.91±0.33	2.27±0.47	p<0.05
		Knee	2.34±0.06	2.29±0.16	p>0.05
		Ankle	0.41±0.02	0.40±0.02	p>0.05
	Extensors	Hip	4.39±0.26	4.14±0.42	p<0.05
		Knee	2.79±0.02	2.81±0.32	p>0.05
		Ankle	1.79±0.26	1.77±0.29	p>0.05
B	Flexors	Hip	1.78±0.31	2.02±0.35	p<0.05
		Knee	2.25±0.11	2.11±0.18	p<0.05
		Ankle	0.36±0.07	0.31±0.09	p<0.05
	Extensors	Hip	4.11±0.17	4.03±0.27	p>0.05
		Knee	2.74±0.12	2.52±0.26	p<0.05
		Ankle	1.61±0.28	1.49±0.21	p<0.05

It is known that the impulse force supported by an excellent high jumper's body is several times larger than the athletes' weight at take-off. If the muscle powers are not balanced among the joints, the performance improvement will be restricted, and the weak ligaments and muscles could get injury easily.
The balance of the leg joints does not mean that the muscle powers among hip, knee and ankle should be equal. It only means the appropriate proportion of the muscle powers is required. However, there is little information concerning this issue.
Regarding the average PT of flexors and extensors on a joint as its muscle power and take knee's PT as100, then the ratio of hip and ankle with knee, as shown in Table 4. As Table 4 shows, the subjects of Group B have weaker muscle power than Group A on ankles of both legs and in right hip. Further study is required to determine whether the above ratios are corresponding to the characteristics of the high jumpers.

Table 4 The Ratio of Three Joints' PT (240°/sec)

Group	Side	Hip	Knee	Ankle
A	Left	123	100	43
	Right	126	100	43
B	Left	131	100	39
	Right	118	100	39

CONCLUSION: The high jumpers' PT of flexors and extensors on hip, knee and ankle declined with the increase in testing speed. Since the Group A declined less than the Group B, it was suggested that there is a stronger muscle power for fast movement in the elite high jumpers.

The muscle power was balanced between the take-off leg's knee and ankle and the swinging leg in Group A. But, the muscle power of swinging leg's knee and ankle was weaker in Group B. The imbalance between the muscle power of the two legs may be a factor attribute to the high jump performance.

The hip flexors' PT of the swinging leg was stronger than that of the take-off leg in both groups. The extensors' PT of the take-off leg was stronger than that of the swinging leg in both groups. These characteristics could improve the performance by increasing the power generated during performing hip extension at take-off phase.

In order to improve performance, the high jumpers should improve their fast muscle power while paying attention to the even distribution of muscle power among hip, knee and ankle. The muscle power training of the ankles and swinging hip will be beneficial for Group B.

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