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STUDY ON KNEE JOINT ISOKINETIC STRENGTH OF MALE VOLLEYBALL PLAYERS

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The purpose of this study is to measure the knee joint mechanics of eight elite volleyball players using isokinetic system and to discuss the possible diagnosis of injury risk of the results. Isokinetic-concentric contraction peak torque of the knee flexors and extensors decreased when angular velocity increased. With the same angular velocity, extension peak torque became higher than flexion peak torque. There was also a significant difference between the left and right knees in each flexion and extension peak torques. As the angular velocity increased, the flexion to extension peak torque ratios decreased; at the same time, average power increased while the work done decreased. The extensors showed greater work done than the flexors. The knee torque curves could be used as evidence for diagnosis of possible knee injury risks among volleyball players.

KEY WORDS: isokinetic strength, knee joint muscle work, knee joint muscle power, volleyball.

INTRODUCTION: Isokinetic system has been widely used in muscle strength training and measurement (Baltzopoulos, 1989).For volleyball players, take-off is a fundamental skill required to better perform spiking and blocking. In this study, the knee joint isokinetic strength of eight elite volleyball players were measured using an isokinetic system (Germany, ISOMED2000). The aim of this study is to gain a understanding of the strength characteristics of the participants and the injury-related critical position of the knee in the range of motion (+10°- +90°) being studied. It is hoped that the information obtained from this study can help coaches improve their scientific training programs in the future.

METHODS: In all, eight male volleyball players (average age 21, height 195.5 cm, hand reaching height 236 cm, weight 90.7 kg, length of training 5.1 years) participated in the study. Among the participants, two were national master sportsmen and four were 1st level national sportsmen. For each participant, the concentric flexion and extension strength of the knee joint at constant angular velocity was measured by ISOMED2000 using the standard testing protocol (Isokinetic M1 con. M2 con). For each flexion and extension, subjects performed 5 repetitions at a low angular velocity (60 degree/s) and 25 repetitions at a high angular velocity (240 degree/s). The biomechanical parameters, including peak torque, relative peak toque (peak torque normalized to body weight), flexion/extension peak torque ratio as well as the work and power, were recorded for each flexion and extension. For each subject, each parameter was averaged across all repetitions of flexion and extension at each velocity and at each side of the knee, respectively. The mean and standard deviations of each parameter among all participants were then computed at each velocity at each side of knee. Two factors ANOVA with repeated measures (legs $\times$ knee rotation direction) was used to determined the difference between legs, different motion directions (flexion or extension) on selected force variables. Significance was set at α=0.05 and Bonferroni adjustment was used to correct multiple measurements.

RESULTS AND DISCUSSION: Muscle Torques: The absolute and relative peak torques along with the flexion/extension peak torque ratios of the knees are presented in Table 1. The absolute and relative peak torques of each flexion and extension of each knee decreased when velocity increased. Our data are consistent with those of the previous study (Carlos and Prietto, 1989). To explain this phenomenon, there occurred a loss of muscle strength in both disconnection and reconnection of the cross-bridges of muscle fibres during muscle contraction. Moreover, the increase of viscous resistance in the contractive components and connective tissues caused by the increase of velocity also influenced the magnitude of the flexors' and extensors' peak torques. Table 1 shows that with the same testing velocity, the extension peak torque is greater than the flexion peak torque ($p<.05$) on each. This implies that the volleyball players participating in this study possessed relatively higher strength and contraction efficiency in knee extensors as compared with the knee flexors.

Table 1
Absolute and Relative Peak Torque of Both Side Knee Flexors and Extensors and Flexor/Extensor Torque Ratio (n=8)

	Velocity (°/s)	Flex. peak torque (N·m)	Flex. relative peak torque (N·m/kg)	Ext. peak torque (N·m)	Ext. relative peak torque (N·m/kg)	Flex./Ext. peak torque ratio
Left	60	187.6±44.5	2.06±0.41	244.5±53.9	2.71±0.59	0.80±0.25
	240	156.2±39.7	1.68±0.34	172.1±41.3	1.88±0.41	0.92±0.19
Right	60	151.4±26.7	1.67±0.23	214.3±63.9	2.39±0.66	0.76±0.23
	240	121.8±35.8	1.32±0.39	144.6±48.6	1.62±0.60	0.88±0.21

The other findings show that each of flexion and extension peak torques of the left knee was greater than those of right knee ($p<.05$) (Table 1). In our study, the dominant leg of all participants was the left leg, which was also the take-off leg. In volleyball, performing single-leg takeoff is necessary for spiking and blocking, which are the key manoeuvres in winning volleyball games. The repetitive take off manoeuvres in daily training and in competition require a highly mechanical demand on the terminal tissues of the knee joints, which might be a major reason of the left knee joint injuries found in these participants.

Muscle work and Power. The work and power of the flexors and extensors of the knee joints are presented in Table 2. As can be seen, as testing velocity increased, the muscle contraction power increased ($p<.06$), whereas the muscle work decreased ($p<.05$). In our experiments, the range of motion of joint flexion and extension was fixed (90°—180°); thus, the working distance of each muscle was the same, and the change of work reflected the change of muscle strength. In addition, as the testing velocity increased, the peak torque decreased (Table 1). The torque refers to the product of the muscle force and the moment arm of the muscle force. Given that the moment arm is constant, the decrease in peak torque can be attributed to the reduced peak muscle force. As the peak strength decreased, the work done also decreased. Regarding the power, as the testing velocity increased, the time for muscles to work decreased at a higher rate than did the muscle strength. As a result, the average power increased. In addition, the work done by knee extensors was larger than that by knee flexors (Table 2).

Table 2
Work and Power Achieved by Flexors and Extensors of both Sides of Knee in Concentric and Isokinetic Contractions (n=8)

	Angular Velocity °/s	Flexors' Work (J)	Flexors' Power (W)	Extensors' Work (J)	Extensor's Power (W)
Left	60	170.4±41.5	131.0±37.7	201.9±48.1	160.1±39.4
	240	131.2±35.1	182.8±50.1	140.0±41.6	205.1±49.8
Right	60	145.9±23.3	102.1±19.2	193.4±43.4	136.0±28.9
	240	95.3±31.7	145.9±56.9	123.9±46.7	188.6±69.7

Contraction Curve. The torque-position curves could provide evidence for better diagnoses of possible injury risks. The normal curve should have the following characteristics (Figure 1): fully parabolic in shape and has a flexion-to-extension ratio falling within the reference range. For some participants, there were two types of curves: one had two peaks and one had a valley (Figure 2), and the other had more than two peaks and valleys (Figure 3). Qu and Yu (2003) have suggested that peritendinitis of the patellar tendon and enthesiopathy of the patellarapex are most serious when the knee angle is at 90°, while the chondromalacia patellaeis is most serious when the knee angle is at 30°—50°. There was also an obvious drop at 76° in the kinetic equipment, which corresponded to 90° in the actual knee joint angle (Figure 2), reflecting a decrease in muscle strength due to pain. This curve well corresponds with the symptoms of enthesiopathy of patellarapex. This drop was observed at 68° - 25° in the isokinetic equipment, which corresponded to 30° - 50° in the actual knee angle (Figure 3). Based on this information, the players could be treated differently for purposive training.

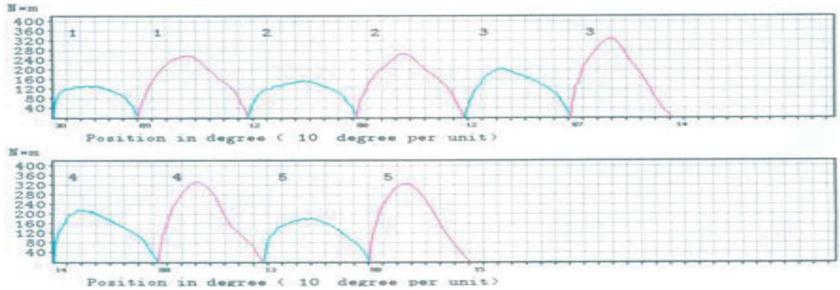

Figure 1: Torque Curve of Normal Knee Joint Isokinetic and Concentric Contraction

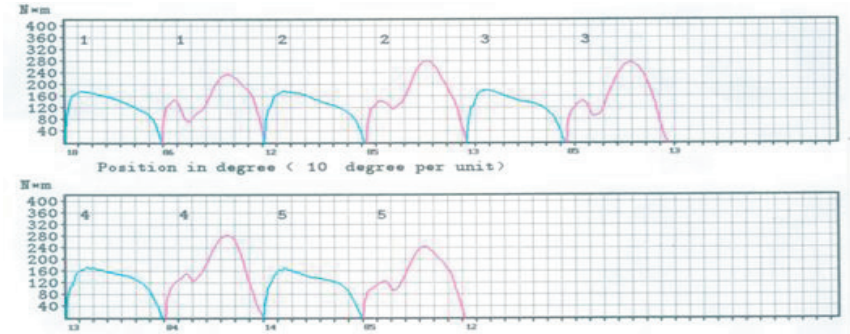

Figure 2: Knee Joint Concentric Contraction Curve with Double Peaks and Single Valley

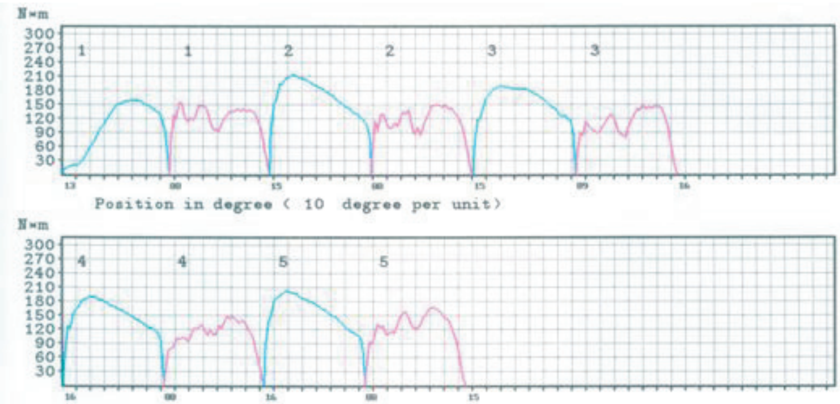

Figure 3: Knee Joint Concentric Contraction Curve with Multi Peaks and Multi Valleys

Conclusion: The isokinetic-concentric contraction peak torque of the knee flexors and extensors decreased when the testing velocity increased. With the same testing velocity, extension peak torque is higher than flexion peak torque reflecting that the volleyball players have lower strength and efficiency in flexors than in the extensors. There is a significant difference between the left and right knees in each flexion and extension peak torques. The average power increased, while the work decreased when the contraction velocity increased (60°/s→240°/s). The extensors showed greater work done than the flexors. The knee torque curves could be used as evidence for diagnosis of possible knee injury risks among volleyball players.

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