

ISOKINETIC PEAK TORQUE OF CONCENTRIC AND ECCENTRIC CONTRACTION IN MALE AND FEMALE

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The purpose of this study was to examine the isokinetic peak torque of plantar flexion and dorsiflexion in male and female. Seventy college students volunteered to participate in this study. Cybex-6000 dynamometer was employed in this study to examine the isokinetic concentric (CON) and eccentric (ECC) strength of ankle plantar flexion and dorsiflexion at 60, 120, 180, 240, and 300°/s. Peak torques (PT) and peak torques relative to body mass for ankle plantar flexion and dorsiflexion were studied. The results indicated that ECC PT was greater than CON PT and plantar flexion PT was greater than dorsiflexion PT in both females and males. The ECC PT did not increase with increasing angular velocity. This study also showed that it was more reasonable to normalize PT relative to body mass when comparing the differences of strength between males and females.

KEY WORDS: ankle, plantar flexion, dorsiflexion, peak torque, concentric, eccentric

INTRODUCTION: Approximately 30 to 50% of injuries reported by athletic teams occur at the ankle joint, most lateral ligamentous complex are affected through inversion injury (Thomas, 1993). Topp (1994) reported that skeletal muscle strength of the lower extremity was an important predictor of activities of daily living and of certain types of morbidity. A number of investigators have reported the importance of lower extremity strength, particularly ankle strength, as a predictor of postural sway, balance, and risk of falling. Another important function of the leg muscles is to serve as the body's shock absorbers. It protected weight-bearing joints from impact forces during gait. Thus, leg strength, particularly plantar flexion and dorsiflexion strength of the muscles of the ankle, appears to be an important predictor of functional status and mobility. However, previous studies of ankle plantar flexion and dorsiflexion strength were limited in comparison to studies of other joints (e.g., knee, shoulder and elbow).

Therefore, the purpose of this study were are: 1) to obtain data on the plantar flexion and dorsiflexion strength of males and females, for concentric and eccentric contraction, that can be used as a basis for studying sports training, sports injury and recovery. 2) to establish relationships between concentric and eccentric contraction relative to different angular velocities of the ankle joint.

METHODS: Physically active females (n=35) and males (n=35) participated in this study. They were provided informed consent. All of them were right-leg dominant. All had asymptomatic ankle function and no previous history of strength training or

involvement in competitive sports emphasizing muscular strength or power. Their physical characteristics are shown in Table 1.

In order to standardize the experiments and localize the muscle actions, subjects were tested in a supine position with stabilizing straps placed around their waists, thighs, and over their shoulders. The ankle dorsi/plantar flexion attachments for the Cybex-6000 were used as indicated in the manual. The lateral malleolus was aligned with the axis of rotation of the machine, and straps were placed across the dorsum of the foot. Synergistic muscle action was avoided by requesting the subjects to hold their arms crossed over their chests during the test procedure. Testing for ankle plantar flexion strength was always performed first. The range of movement was from 80 to 120 degrees, with 90 degrees representing the anatomical position.

Subjects were provided with instructions on the purpose of the testing and given time to familiarize themselves with the testing equipment. The warm-up trials consisted of five submaximal contractions progressing in intensity from approximately 50 to 100% exertion. The plantar flexion and dorsiflexion muscle groups were examined in the following order: concentric plantar (PLAN_{CON}), concentric dorsiflexion (DOR_{CON}), eccentric plantar (PLAN_{ECC}), and eccentric dorsiflexion (DOR_{ECC}). The CON muscle actions were performed prior to ECC muscle actions, since a series of maximum ECC muscle actions may reduce CON torque production; whereas a series of maximum CON muscle actions appears not to influence maximum ECC torque production. The CON and ECC muscle actions were accomplished at constant angular velocities in the following order 60, 120, 180, 240, and 300°s⁻¹. Three trials were allowed at each angular velocity. The torque curves produced during muscle action were recorded and the peak torque (PT) was subsequently identified.

Means and standard deviations (SD) were calculated and a Studentized Range test was used. The level of significance was set at p<0.05. All results presented as different to that level fulfils the required criterion.

Table 1 Physical Characteristics of Subjects (Mean ± SD)

	Males (n=35)	Females (n=35)
Age(years)	19.9 ± 1.1	20.2 ± 1.3
Height(cm)	170.3 ± 5.9	158.4 ± 5.6
Mass(kg)	62.0 ± 8.6	53.2 ± 6.4
Calf perimeter(cm)	35.8 ± 2.5	35.3 ± 2.2

RESULTS: The ECC and CON torque-velocity patterns for PLAN and DOR are shown in Figures 1 and 2. The ECC and CON testing data for PLAN and DOR are shown in Tables 2 and 3.

Table 2 Peak Torque (Nm) for Plantar Flexion and Dorsiflexion for Concentric and Eccentric Muscular Contractions

Angular Velocity (deg s ⁻¹)	Plantar Flexion					
	Concentric			Eccentric		
	Female	Male	Ratio*	Female	Male	Ratio*
60	40.1±10.0	57.0± 4.1	0.70	74.6±18.3**	104.2±25.2* *	0.72
120	30.3±7.2	41.1±10.3	0.74	70.8±17.2**	101.0±24.8* *	0.70
180	23.7±7.1	32.4±8.5	0.73	69.4±15.4**	99.7±21.7* *	0.70
240	20.7±6.0	27.0±7.1	0.77	68.5±16.2**	96.8±23.1* *	0.71
300	19.7±5.5	25.8±6.5	0.76	65.8±16.3**	97.5±20.0* *	0.67

Angular Velocity (deg s ⁻¹)	Dorsiflexion					
	Concentric			Eccentric		
	Female	Male	Ratio*	Female	Male	Ratio*
60	13.9±3.9	19.5±4.1	0.71	28.7±7.5**	42.6±7.6**	0.67
120	9.8±2.3	13.4±2.9	0.73	27.3±6.8**	40.7±7.6**	0.67
180	8.4±2.2	11.0±2.4	0.76	27.7±6.8**	39.8±7.1**	0.70
240	7.3±2.3	9.6±2.6	0.76	28.3±7.1**	40.6±7.2**	0.70
300	5.1±2.5	7.6±2.2	0.67	29.0±7.0**	41.0±7.8**	0.71

Values are mean ±SD.

*Ratio shows peak torque in female relative to male.

**p≤.05.

Table 3 Peak Torque Relative to Body Mass (Nmkg⁻¹) for Plantar Flexion and Dorsiflexion for Concentric and Eccentric Muscular Contractions

Angular Velocity (deg s ⁻¹)	Plantar Flexion*					
	Concentric			Eccentric		
	Female	Male	Ratio**	Female	Male	Ratio**
60	0.75±0.20	0.93±0.24	0.81	1.41±0.38	1.69±0.41	0.83
120	0.57±0.15	0.67±0.19	0.85	1.34±0.36	1.64±0.41	0.82
180	0.45±0.14	0.53±0.15	0.85	1.32±0.34	1.62±0.36	0.81
240	0.39±0.12	0.44±0.12	0.89	1.30±0.36	1.57±0.37	0.83
300	0.37±0.11	0.42±0.11	0.88	1.25±0.34	1.59±0.34	0.79
Angular Velocity (deg s ⁻¹)	Dorsiflexion					
	Concentric			Eccentric		
	Female	Male	Ratio*	Female	Male	Ratio*
60	0.26±0.06	0.31±0.06	0.84	0.53±0.11	0.69±0.11	0.77
120	0.18±0.04	0.21±0.05	0.86	0.51±0.10	0.65±0.10	0.78
180	0.15±0.04	0.18±0.04	0.83	0.51±0.09	0.64±0.09	0.80
240	0.13±0.04	0.15±0.04	0.87	0.53±0.10	0.65±0.10	0.82
300	0.09±0.04	0.12±0.04	0.75	0.54±0.10	0.66±0.11	0.82

Values are mean ±SD.

*Ratio shows peak torque in female relative to male.

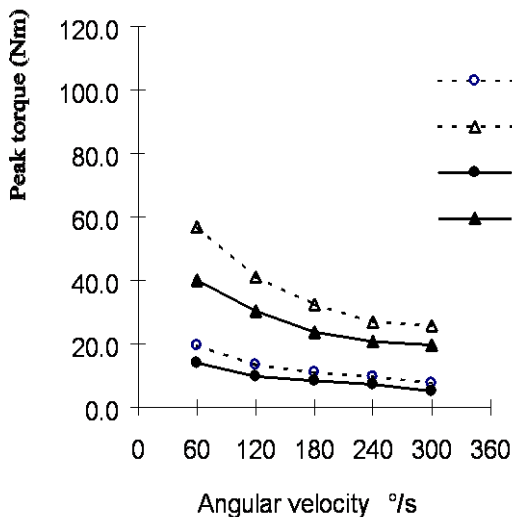


Figure 1 - Mean concentric peak torque for plantar flexion and dorsiflexion in males and females.

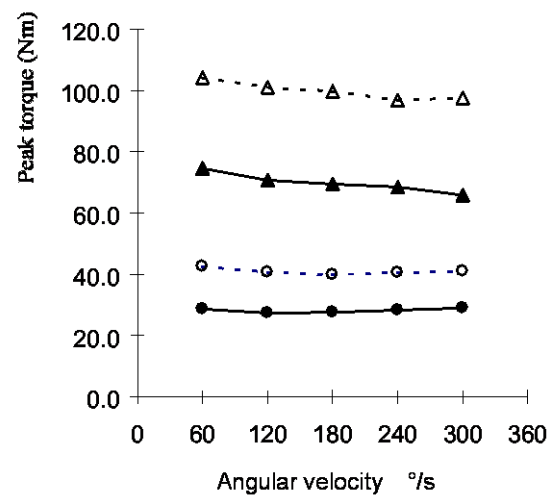


Figure 2 - Mean eccentric peak torque for plantar flexion and dorsiflexion in males and females.

DISCUSSION: In the present study, it was found that $PLAN_{CON}$ and DOR_{CON} PT decreased with increasing angular velocity. The present data yielded muscular contraction patterns similar to those shown for other joints (knee, elbow and hip) i.e. the peak torque decreased with increased angular velocity. The torque-velocity relation, calculated from isokinetic measurements, may be influenced by fiber type, neuromuscular control, and biomechanical properties of the muscle groups tested. Force-velocity characteristics have been correlated to muscle fiber composition. In the present study, a lower torque-velocity ratio was found for dorsiflexion than for plantar flexion. Because the muscle groups were tested as functional units, no conclusions about separate muscle characteristics can be made. The shape of the curves was different for the two motions. The plantar flexors showed a more marked peak than did the dorsal flexors. This indicated a difference in functional demands and may reflect the change in mechanics that occurs during contraction. Some studies showed that the line of action is constant for the tibialis anterior, but changes during motion for the gastrocnemius.

The torque-velocity relationship of ECC muscle actions in the present study revealed different patterns for plantar flexion and dorsiflexion. The $PLAN_{ECC}$ PT decreased, whereas DOR_{ECC} PT showed no change with increasing angular velocity. Previous studies, examining elbow flexors, were not conclusive as to whether or not eccentric force increases at angular velocities comparable to those reported in this study (Komi, 1973; Rodgers & Berger, 1974). Therefore, it is suggested that ECC PT does not necessarily increase as a function of angular velocity. It is probably that the neural mechanism might become active during maximal contractions of intact systems, thus restricting the maximal tension in a muscle by an inhibitory feedback loop. Besides, since the potential for very high levels of muscle tension is so great during eccentric contractions, the subjects were unable to overcome the neural inhibition during these conditions. As a result their eccentric strength was leveled out.

The $PLAN_{ECC}$ PT was greater than $PLAN_{CON}$ PT. The DOR_{ECC} PT was greater than DOR_{CON} PT at all angular velocities. In general, males displayed higher absolute PT than females at all muscle action modes and all angular velocities. Males showed on average 26% greater CON PT and 30% greater ECC PT than females. Hence, males showed 15% and 19% greater peak torque, per unit of body mass, than females for CON and ECC modes, respectively. These findings suggest that it was more reasonable to normalize PT relative to body mass when comparing the differences of strength between males and females.

CONCLUSION: This study demonstrated ECC PT to be higher than CON PT and plantar PT to be higher than dorsal PT in both females and males. The ECC peak torque did not increase with increasing angular velocity. Therefore, it has been suggested that ECC peak torque did not necessarily increase as a function of increasing angular velocity. This study showed it was more reasonable to assume with PT relative to body mass than PT when comparing the differences of muscular strength between males and females.

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Acknowledgments

This study was supported by research funds from the National Institute of Sports Science. The author wishes to also thank adjunct Prof. Liu Xuezheng and Prof. Lu Deming for their valuable comments while preparing this manuscript.