Greater knee muscular strength during high velocity movement among practitioners of taekwondo

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Introduction

Taekwondo (TKD) training places emphasis on fast and high kicks. Thus, the practice of TKD may be beneficial for strengthening lower-limb muscles in young people. The objective of our study was to compare isokinetic knee muscular strength between TKD practitioners and control participants during movement at different velocities.

Material and methods

Sixty-eight TKD practitioners and 72 age- and sex-matched control participants were enrolled in our study. Body height and weight were measured using a mechanical scale with an attached height rod. Measurements of the isokinetic peak torque for knee extension and flexion were recorded at 60°/s, 180°/s, and 240°/s using a Cybex Norm isokinetic dynamometer.

Results

Results revealed that the isokinetic peak-torque values for knee extension and flexion at 240°/s were 11.5% and 16.6% higher, respectively, in the TKD group than in the control group (P < 0.05). No significant intergroup difference in knee muscular strength was found at the lower angular velocities (60°/s and 180°/s).

Conclusions

The practice of TKD may be beneficial for improving knee muscular strength in adolescents, especially with regard to the repetition of high-velocity movements.

Summary

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Introduction

Taekwondo (TKD) is a martial art that originated in Korea. It is famous for its fast and high kicks. Indeed, approximately 80% of all TKD techniques are related to kicking [1,2,3]. Lower-limb muscular strength is, therefore, particularly important for achieving optimal results in TKD training and competition [4], and may help prevent sports-related injuries [5]. Existing evidence suggests that TKD training may improve lower-limb muscle strength in elite athletes [6,7], recreational athletes [7,8,9], and children with developmental coordination disorder [10].

However, relatively small sample sizes were used in these previous studies. Thus, the statistical power associated with such findings is low. In addition, the use of various testing methods, including field tests, isometric manual muscle testing, and isokinetic tests, impedes comparisons of the data from these studies [7]. As muscle training is velocity specific, isokinetic testing may be the most appropriate method to differentiate muscular strength at different velocities of movement in TKD practitioners [9,11]. Therefore, the major objective of our study was to compare the isokinetic knee muscular strength between TKD practitioners and control participants during movement at three different velocities.

Material and methods

Sixty-eight recreational TKD practitioners between the ages of 10 and 17 years and 72 age- and sex-matched control participants (Table 1) were recruited from three local TKD associations and the community. All TKD participants had trained in TKD for a minimum of two years, with a training frequency of two sessions per week (1 to 1.5 h/session). Participants in the control group had sedentary lifestyle and did not have any experience in TKD. The exclusion criteria (for both groups) were (a) significant cardiopulmonary, neurological, or musculoskeletal disorders; (b) a history of injury during the preceding 12 months that required medical attention; and (c) regular involvement in sports other than TKD. Our study was approved by the Human Subjects Ethics Review Committee of the administering University, and all procedures were conducted in accordance with the Declaration of Helsinki.
ten, informed consent was received from all participants prior to participation in our study. Relevant medical history was obtained from both the adolescents and their parents before their participation in the physical assessments.

The body height and weight of each participant was measured using a 420KL Physician Scale with an attached height rod (Health-O-Meter, Bridgeview, IL, USA) before their participation in the isokinetic tests. Knee muscular strength was quantitatively assessed using a Cybex Norm isokinetic dynamometer (Computer Sports Medicine, Stoughton, MA, USA). Only the dominant leg, defined as the leg used to kick a ball, was tested because a previous study had shown no significant differences in the isokinetic peak-torque values for knee extension and knee flexion between the dominant and non-dominant legs of young people [12].

During isokinetic testing, participants were seated with their hips at 85° of flexion and the tested knee at 90° of flexion. Seat belts were used to stabilize the trunk and pelvis, and the thigh of the tested leg was stabilized using a thigh strap. The knee-joint axis, demarcated by the lateral epicondyle of the knee, was aligned to the rotational axis of the dynamometer. The maximum concentric contractions of the knee extensors and flexors were measured in sequence at 60°/s, 180°/s, and 240°/s. Gravitational effects on knee torque were corrected before performing three familiarization trials. During the actual test, three continuous extension/flexion cycles throughout the full range of motion of the knee were performed. Participants were given a 10-s rest period before testing resumed at a different velocity. The average peak torque value for knee extension and flexion at each velocity was used for analysis [13].

All statistical analyses were performed using the SPSS computer software, version 20.0 (IBM, Armonk, NY, USA). The normality of the data was verified using the Kolmogorov-Smirnov test. Independent t-tests and chi-squared tests were used to compare the age, height, weight, and body mass index (continuous variables) and sex (categorical variable), respectively, between the control and TKD groups. A multivariate analysis of covariance (MANCOVA) was used to compare the isokinetic peak torque values for knee flexion and extension between the two groups while controlling for age and sex as possible confounding factors [14,15]. The MANCOVA incorporated all outcome measures, including peak torque values for knee flexion and extension at 60°/s, 180°/s, and 240°/s, with the study group (TKD versus control adolescents) as the fixed factor and age and sex as the covariates. The results of the MANCOVA showed the group effect on all outcome measures and the corresponding Bonferroni-adjusted P values. We used this analysis is to avoid the type I errors often associated with multiple comparisons. The significance level was set at α = 0.05 (two-tailed). The effect sizes of the outcome variables were calculated as partial eta-squared values, with values of 0.01, 0.06, and 0.14 representing small, medium, and large effect sizes, respectively [16].

Results

The demographic characteristics of all participants are presented in Table 1. The results of the MANCOVA revealed a significant overall difference in knee muscular strength between the study groups (Hotelling trace = 0.364, P < 0.001). When each individual outcome measure was considered, only the isokinetic peak torque values for knee extension and flexion at 240°/s were significantly higher (11.5% and 16.6%, respectively) in the TKD group than the control group (P < 0.05). Partial-eta-squared values ranged from 0.042 to 0.050, indicating medium effect sizes (Table 2). Moreover, no signifi-
icant intergroup difference in knee muscular strength was observed at lower angular velocities (Table 2).

**Discussion**

Our results revealed that adolescent TKD practitioners had higher isokinetic peak torque values for knee extension and flexion during high velocity movement (240º/s), compared with the control participants, but not at lower movement velocities (60º/s and 180º/s). Our findings are consistent with those of previous studies that reported young, recreational TKD practitioners had higher isokinetic peak torque values for high-velocity knee movement only (240º/s) [8,9]. This phenomenon may be explained by the training mode of TKD. During TKD training, much emphasis is placed on executing powerful kicks [1]. Indeed, the kicking forces generated by TKD practitioners are very high, ranging from 408.4 N to 606.9 N in one study [15]. The practice of TKD may be a beneficial dynamic-strengthening exercise for the lower-limb muscles in young people [9]. In addition, a previous kinematic study reported a maximum knee angular velocity of 874.3º/s for a roundhouse kick [17]. Thus, TKD-trained adolescents may demonstrate higher knee muscular strength during high velocity movement than their untrained peers because muscle training is velocity specific. Strengthening a muscle at high (angular) velocities facilitates the development of fast-contracting muscle fibers, preferentially improving high-velocity muscular strength [11]. Although the velocities used in our study (60º/s, 180º/s, and 240º/s) were lower than that of the previously reported maximum kicking velocity (874.3º/s), our results indicated that practice kicking at 240º/s may be sufficient for the strengthening of fast muscle fibers.

In contrast to our current findings, a previous study reported that the isokinetic peak torque generated during knee extension and flexion in hard-style martial-arts practitioners were higher than that of the control participants at both low (30º/s and 90º/s) and high (210º/s) movement velocities. However, the mean ages of their martial-arts and control participants were older (23.7 and 22.2 years, respectively) than our TKD and control groups, who had an average age of 14 years [18]. Physical maturation and heterogeneity in the type of martial art practiced (TKD, Shaolin Kung Fu, and Wushu) may have altered the effect of training in the martial-arts practitioners [18], contributing to the discrepancies between our findings and those of O’Donovan et al [18].

The cross-sectional design of our study represents a possible limitation to the interpretation of our findings. It is unclear whether intergroup differences in muscle strength are the result of natural factors, such as genetic predisposition, or behavioral factors (TKD training). Further prospective, randomized controlled trials are warranted to confirm our findings regarding the muscle-strengthening effects of TKD training.

**Conclusions**

1. TKD practitioners generated higher isokinetic peak torque during high-velocity knee extension and flexion, compared with age- and sex-matched control participants, but not during movement at lower velocities.
2. The practice of TKD may be one of the beneficial exercises for improving knee muscular strength, especially with regard to high-velocity training techniques in adolescents.

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**References**


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