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# Isokinetic dynamometry of the knee extensors and flexors in Iranian healthy males and females

Mandana Rezaei[1], Ismael Ebrahimi[2], Behnoush Vassaghi- Gharamaleki[3]
Milad Pirali[4], Niyousha Mortaza[5], Kazem Malmir[6], Kobra Ghasemi[7], Ali A. Jamshidi[8]

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## Abstract

**Background**: This paper explores the gender-related bilateral differences of extensor and flexor torques of the knee joint at low and high angular velocities in Iranian healthy males and females.

**Methods**: 70 healthy subjects (29 males (26.61±4.34 yrs and 41 females with average age of 23.07±3.70 yrs)) were participated in this study. Isokinetic peak torque values for knee extensors and flexors in concentric and eccentric contraction modes were measured and flexors and extensors strength ratios (HQR) computed among both dominant and non-dominant legs in lying position at 60 and 180°.s-1angular velocities.

**Results**: There was significant gender-velocity interactions detected for knee flexor to extensor strength ratios presenting that increasing velocity escaled this, ratios in females more than males ($p<0.05$). There was no gender-velocity-leg side interaction ($p>0.05$). Bilateral differences were found for eccentric flexor peak torques ($p<0.05$). By increasing velocity, peak torque values decreased and HQR was increased ($p<0.05$).

**Conclusion**: Measurement procedures including test position is an important factor when interpreting gender-related and bilateral differences of isokinetic knee strength ratios in healthy individuals.

**Keywords**: Knee, Isokinetic dynamometry, Strength ratio, Gender.

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## Introduction

Isokinetic dynamometers are used widely for testing and rehabilitation in various injuries (1). These dynamometers express strength as torques at multiple constant angular velocities (2). Evaluation of muscle strength characteristics at various angular velocities has provided us with a better understanding of the knee joint function. Reliability (3,4) and validity (3-6) of isokinetic torque measurement were reported good to excellent while reliability in lower velocities reached high (5). Knee extensor torques were reported to be higher than flexor ones (6). Concentric flexor torque to concentric extensor torque or conventional ratio ($H_{con}$:$Q_{con}$) (7-9) and eccentric flexor torque to concentric extensor torque or dynamic control ratio ($H_{ecc}$:$Q_{con}$) (1-10) have been both used extensively in different untrained and athletic population to characterize strength profile of the knee joint. Higher values of knee isokinetic torques have been found in males to females (11-14), but there

1. PhD student, School of Rehabilitation, Iran University of Medical Sciences, Tehran, Iran. mandana.rezae@gmail.com
2. Full Professor, School of Rehabilitation, Iran University of Medical Sciences, & Rehabilitation Research Center, Biomechanics Lab, Iran University of Medical Sciences, Tehran, Iran. ebrahimi.pt@gmail.com
3. Assistant Professor, School of Rehabilitation, Iran University of Medical Sciences, & Rehabilitation Research Center, Biomechanics Lab, Iran University of Medical Sciences, Tehran, Iran. vasaghi.b@iums.ac.ir
4. Msc, Islamic Azad University of Tehran Central branch, Tehran, Iran, Rehabilitation Research Center, Biomechanics Lab, Iran University of Medical Sciences, Tehran, Iran. milad.pirali5@gmail.com
5. Msc, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia. niyusha_m@yahoo.com
6. PhD student, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran. kazemmalmir@gmail.com
7. PhD student, School of Rehabilitation, Iran University of Medical Sciences, Tehran, Iran. koohestan_3000@yahoo.com
8. (**Corresponding author**) Assistant Professor, School of Rehabilitation, Iran University of Medical Sciences, & Rehabilitation Research Center, Biomechanics Lab, Iran University of Medical Sciences, Tehran, Iran. aliajamshidi@yahoo.com

have been controversy about the ratios (12,14-17); many investigators have declared that with increasing velocity, $H_{con}$:$Q_{con}$ (12,15-18) can increase the $H_{ecc}$:$Q_{con}$ (6,10,19) ratios. No gender differences in $H_{con}$:$Qc_{on}$ ratio was reported in healthy subjects although a leg velocity interaction affected by increased velocity and higher H:Q ratio obtained in dominant leg compared to the non-dominant one (15). There was no data on $H_{ecc}$:$Q_{con}$ ratio in healthy individuals. Evaluation of isokinetic eccentric antagonistic strength relative to concentric agonist strength may be a valuable tool in describing the maximal potential of the antagonistic muscle group. It might be more useful in determining an injury risk compared to the conventional $H_{con}$:$Q_{con}$ ratio (7, 20). The method of measurement including test position can have influence on strength of measures for the knee joint (1,21). It has been reported that changes in hip and knee joint positions have a predominant effect on activation level of quadriceps muscle during maximal voluntary isometric (22-24) and concentric contractions (22). Although previous studies demonstrated lower activation levels (23, 24) and moment output of quadriceps muscle (24, 25) in lying position of the hip joint, but little is known in regard to the gender and bilateral differences in H:Q ratios at various velocities in this position. It seems that evaluation of the knee strength parameters in lying position is more similar to the position of functional activities (26). Therefore, the purpose of the present study was to compare the knee flexor and extensor torque and ratios in healthy males and females in lying position with respect to velocity and leg dominance.

## Methods

### *Subjects*

Seventy healthy university students (29 males and 41 females) participated in this study (Table 1). These subjects had neither a history of knee abnormalities nor problems such as musculoskeletal injuries that needed treatment during the previous year. The study was approved by Ethics Committee of Iran University of Medical Sciences and informed written consent was obtained from each subject. We defined leg dominance as the preferred kicking leg.

### *Experimental procedures*

Knee flexor and extensor torques were measured by isokinetic dynamometer Biodex System 3 [Biodex Medical Systems, Inc, New York, USA] at 60 and 180°.$s^{-1}$ (1). After warm-up, subjects were familiarized with all testing procedures and equipment with submaximal effort before data collection. The right knee was tested first irrespective of leg dominance. All tests were given in lying position. Knee extensor and flexor strengths were measured in lying position (supine and prone positions), respectively. Inclination angle for the seat was 25 degrees from horizontal position. Subjects were secured to the dynamometer seat with straps across the chest and thighs. The center of the knee joint (lateral epicondyle of femur) was aligned with the center of the dynamometer's power shaft. The resistance pad was placed on the distal two third of the tibia. Range of motion was set between 10-90 degrees of knee flexion. The gravity correction was performed by the dynamometer. Two minutes rest interval between trials was considered a preventive measure for fatigue (26). During all test protocols, subjects were provided with visual feedback for torque and encouraged to maintain the maximal torque. Peak torque (PT) values at each condition were recorded by the Biodex software and the highest torques value of the data set was used in the statistical analysis.

PT values were presented as normalized values to body weight (4, 12, 20).

Moreover, the conventional ratio of concentric flexor PT to concentric extensor PT [$H_{con}$:$Q_{con}$ ratio], and functional ratio of eccentric flexor PT to concentric extensor PT [$H_{ecc}$:$Q_{con}$ ratio] were calculated using equation below:

H:Q ratio= peak flexor torque/peak extensor torque * 100%

Table 1. Descriptive characteristics of the subjects

| | All (n=70) | Males (n=29) | Females (n=41) | p |
|---|---|---|---|---|
| Age (y) | 24.10(4.14) | 26.61(4.34) | 23.07(3.70) | 0.011* |
| Weight (kg) | 62.88(11.88) | 72.37(8.78) | 56.47(9.11) | <0.001* |
| Height (cm) | 170.07(9.19) | 178.83(5.78) | 164.38(5.92) | <0.001* |
| Body mass index ($kg.m^{-2}$) | 21.60(2.94) | 22.77(3.02) | 20.84(2.66) | 0.008* |

Values are expressed as mean (± SD). *Significant difference between males and females compared using independent t-tests.

In the pilot study, measurements for knee extensor and flexor isokinetic torques were performed in conventional seated position (15) in 15 males and 14 females. Results were consistent with other literatures (14, 15). Details were discussed in discussion section.

### *Statistical analysis*

Repeated measures analysis of variance was used for analysis of the interaction in gender (male vs. female), leg dominance [dominant (D) vs. non-dominant (ND) legs) and velocity (60 vs. 180°.$s^{-1}$). Levenes's test of Equality of Error Variances box was checked first to examine whether the assumption of homogeneity of variances was violated. The significance level was set at 0.05 for all statistical procedures.

## Results

Means and standard deviations of absolute PT values of both flexors and extensors and ratios at each velocity, are respectively presented in Table 2,3.

A combined between-within subjects analysis of variance was conducted to assess the impact of gender on PT verses body weight of dominant and non-dominant legs at two test velocities (60 and 180°.$s^{-1}$ ).

There was no notable gender-leg dominance-velocity interaction and gender-leg dominance-interactions effect. The significant gender-velocity interactions were detected for $H_{con}$: $Q_{con}$ (F(1,48)= 6.719, p=0.013) and $H_{ecc}$: $Q_{con}$ (F(1,47)= 10.300, p= 0.002) ratios showing that with increasing velocity, ratios were increased greater in females than males. The main effect that compared genders was significant for all values (p< 0.001) suggesting higher PT to body weight values for males and higher H: Q ratio values for females. There was a substantial main effect for leg dominance, (F(1,49)= 4.463, p= 0.040) for both genders showing higher eccentric flexor PT values in D vs. ND leg. The main effect of velocity is significant for concentric extensor PTs to body weight (F(1,49)= 184.900, p= 0.000), concentric flexors PTs to body weight (F(1,49)= 5.038, p= 0.029), $H_{con}$:

Table 2. Mean (± SD) values of absolute peak torque values

| Gender | | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|---|
| Torque | | Dominant | | Non-dominant | | Dominant | | Non-dominant | |
| | | 60 | 180 | 60 | 180 | 60 | 180 | 60 | 180 |
| Concentric | Extensor | 221.46 (55.96) | 177.46 (40.43) | 219.42 (47.08) | 175.99 (49.26) | 108.85 (29.27) | 90.4 (32.67) | 110.92 (26.34) | 82.45 (21.14) |
| | Flexor | 105.33 (32.87) | 98.77 (24.77) | 102.40 (33.37) | 98.21 (22.59) | 49.1 (20.54) | 52.56 (21.44) | 51.82 (18.63) | 50.62 (16.45) |
| Eccentric | Extensor | 280.96 (86.83) | 283.38 (59.57) | 285.64 (68.50) | 285.86 (66.46) | 152.11 (55.03) | 149.16 (43.77) | 141.92 (52.41) | 147.49 (47.98) |
| | Flexor | 107.04 (29.29) | 109.63 (24.32) | 103.08 (24.48) | 107.30 (24.03) | 63.55 (16.42) | 62.20 (17.24) | 58.82 (18.12) | 61.06 (16.69) |

Table 3. Mean (± SD) values of absolute ratios

| Gender | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Dominant | | Non-Dominant | | Dominant | | Non-Dominant | |
| Ratio | 60 | 180 | 60 | 180 | 60 | 180 | 60 | 180 |
| $H_{con}$:$Q_{con}$ ratio | 0.48 (0.12) | 0.56 (0.11) | 0.46 (0.10) | 0.57 (0.13) | 0.44 (0.13) | 0.59 (0.15) | 0.47 (0.11) | 0.62 (0.15) |
| $H_{ecc}$:$Q_{con}$ ratio | 0.50 (0.15) | 0.63 (0.12) | 0.48 (0.09) | 0.63 (0.12) | 0.56 (0.13) | 0.69 (0.14) | 0.53 (0.10) | 0.75 (0.16) |

$Q_{con}$ ratio ($F(1,48)= 46.146$, $p= 0.000$) and $H_{ecc}$: $Q_{con}$ ratio ($F(1,47)=114.009$, $p=0.000$) showing that as the angular velocity increased, extensor and flexor PTs to body weight decreased and ratio increased.

## Discussion

This study compared bilateral strength characteristics of the knee flexors and extensors in healthy Iranian males and females at 60 and 180°.$s^{-1}$. Our main findings were: 1) peak torques were higher in males than females but H:Q ratios in females were higher than males; 2) bilateral differences between dominant and non-dominant legs were found for eccentric flexor PTs and there was no difference in H:Q ratios; 3) force-velocity relationship was evident for concentric PTs and PTs and eccentric flexor PTs and 4) with increasing velocity, H:Q ratios increased.

In the previous studies, $H_{con}$: $Q_{con}$ was used widely to address muscle strength imbalances in different populations (4,8,12,16,18,20). Evaluation of knee isokinetic eccentric antagonistic strength relative to concentric agonist strength may provide a valuable relationship in describing the maximal potential abilities of the antagonistic muscle groups. It is appeared that knee joint dynamometry is affected by hip joint position due to length-tension relationship of biarticular muscles. Change in hip (24) and knee (22) joint position can have effect on quadriceps activity. For example a lower activation of rectus femoris muscle (24) and a lower quadriceps muscle moment (25) reported in lying position compared to the seated position. In the pilot study, isokinetic knee flexor and extensor torques were measured in conventional seated position (15) with regard to bilateral and gender differences. Finally the H:Q ratios were calculated in this position. Results showed that with increasing velocity, ratios increased in both males and females and there were no bilateral and gender differences. These results were consistent with other literatures (14, 15). Therefore, this study was conducted in lying position to demonstrate the effect of this position on knee strength profile. It is the first studythat compared the H: Q ratios among gender with respect to velocity in lying position.

In our study, H: Q ratios in females were higher than males. These results were inconsistent with others who reported no gender differences in the ratios (11,12,15,16). Other investigators reported higher H: Q ratios in males compared to females (14,28). Gender velocity interaction (higher values at higher velocity in females comparing to males) found in our study was in contrast with the results of a systematic review including studies used seated test position. They declared that males demonstrated a significant increase in the H: Q ratio at higher velocities (28). The H: Q ratio could be related to increased risk of injury in females (29). Extensor peak torques differences between males and females were greater than the knee flexors while both parameters reached significant level and it may account for high H: Q ratios in females(according to the Table 3). Worrell, et al. also reported larger gender difference between knee extensor torques than flexors torques in supine position (10º of hip flexion) of isokinetic testing. However they reported only concentric torques (25). These results show that performing isokinetic assessment may be affected by joint position and its influence on bi-and mono-articular muscles in different contraction modes. Previous studies demonstrated different activation levels (23, 24) and concentric torque output of quadriceps (24, 25) and hamstring muscles (30) in the lying position of the hip joint. However the activation pattern of quadriceps and hamstring muscles with regard to gender-related differences in this position is not khown. These results have implication for knee joint injury prevention and post-injury rehabilitation programs considering the effect of training status and hip joint position especially for athletic population.

We observed bilateral differences for eccentric flexor PTs at both of velocities. There were no bilateral differences between legs for ratios. These results are in agreement with the study of Yoon, et al. (14) who were not reported bilateral differences in ratios but are inconsistent with the study of Kong, et al. (15). This disagreement may related to testing position. They measured H: Q ratios in seated position (15) but we used lying position for measurement. In addition, they only reported the results of changes in $H_{con}$: $Q_{con}$ ratios because of technical problems in data acquisition (15) but we also computed functional $H_{ecc}$: $Q_{con}$ ratios. Our results of flexor PTs are consistent with others (4,15,29).

Concentric extensor and flexor PTs were in lower 180° rather than 60°.s$^{-1}$. But ratios were in higher 180° instead of 60°.s$^{-1}$. We did not found any significant differences for eccentric extensor PTs. Our results are in agreement with others (10,12,15,16,18, 29).

## Conclusion

We observed significant gender-velocity interactions for knee H: Q ratios representing that with increasing velocity, ratio increased much higher in females than males. There was no gender-velocity-leg dominance interaction. Bilateral differences were found for eccentric flexor peak torques. By increasing velocity, peak torques values decreased and ratio increased.

Gender related differences existed in torque and ratio values are dependent on many factors such as measurement procedures. The application of lying test position for strength measurement in the knee joint can give us new insights about knee strength profile considering the role of bi- and mono-articular muscles acting on the knee joint.

We suggest evaluation of the knee strength characteristics in lying position at velocity spectrum in different populations with regard to training status and adolescence.

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