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RELATIONSHIP BETWEEN THE THIGH ANTHROPOMETRIC MEASUREMENTS WITH ISOKINETIC PERFORMANCE OF KNEE MUSCLES

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ABSTRACT

Background: Strength measurement is an essential component of assessment in rehabilitation. However, there may be many factors that may alter muscle performance, among which anthropometric values play a significant role. Therefore, the objective of this study is to find out the correlation between thigh anthropometric measurements with the knee isokinetic muscle performance.

Methods: Eighteen young, healthy male adults, whose mean age was of 21.22 ± 1.39 were included. Anthropometric measurements like height, weight, thigh girth, and femoral length were correlated with isokinetic strength of knee flexor and extensor muscles. The variables collected in isokinetic measurements; used for analysis were peak torque at three angular velocities of 60°/s, 120°/s, and 180°/s.

Results: The Pearson correlation between the thigh girth and isokinetic peak torque at angular velocities of 60º/s, 120º/s, and 180º/s for knee extensors were, $r = 0.52$, 0.69 and 0.73 whereas for knee flexors it was $r = 0.53$, 0.24 and 0.44 respectively which showed moderate to high correlation when the level of significance was kept at 0.05. However, the correlation between the femoral length and isokinetic peak torque at three angular velocities for knee muscles showed a weak positive correlation only.

Conclusion: Study results show that there is a moderate to strong positive correlation exists between thigh girth and isokinetic peak torque of knee musculature, whereas there is only a weak correlation exists between femoral length and isokinetic peak torque of knee musculature. Therefore, it reveals that the length of the extremity does not seem to influence the outcome of isokinetic measurement values. In contrast, the girth of the muscle can influence the outcome of the isokinetic measurement values, especially for the knee joint.

Keywords: Knee, Isokinetic Peak Torque, Femoral Length, Thigh Girth, Muscle Strength.

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INTRODUCTION

Strength measurement of a muscle is an essential component of assessment in rehabilitation. Muscle strength assessment is continued even throughout the management process as it gives a quick and valid reevaluation of the patient's progress [1, 2]. The definition of muscle strength can be described as the maximum torque produced by a group of muscles in a particular joint while performing an active contraction [3]. The strength of muscle is tested and trained regularly, especially the muscles of the knee by isokinetic dynamometry in sports and rehabilitation [4]. The strength can be quantitatively measured with an isokinetic dynamometry in which the resistance, velocity, and position of the joint are tightly controlled [5]. Currently, isokinetic dynamometry has gained popularity among the rehabilitation team because, in the constant preselected velocity of movement and dynamic conditions, it measures the optimal loading of the muscles. Hence, many clinicians have considered the isokinetic dynamometry as an objective method of assessment to measure the knee muscle balance and to develop various rehabilitation protocols depending on the type of disease or injury [6].

Torque is the common terminology used to express the muscle strength, and this can be explained as the product of the muscle exertion force with its lever-arm length. With isokinetic dynamometry, the strength of the muscle can be assessed in various modes like; isometric, isotonic, and even in an isokinetic mode. Usually, the isokinetic mode has been used in clinical settings over the last few years due to its specificity [7]. By using the isokinetic contraction, the maximal strength of a particular muscle can be assessed, and that's the reason why the isokinetic dynamometry device has been widely used world over. In further, the isokinetic dynamometry determines the strength as well as the function of a joint [8].

The force production in a muscle could be varied according to the surface anthropometry. But so far, these thoughts have not been confirmed explicitly. The strength of the muscle could be related to the body anthropometrics; however, these associations were not established for the knee extensors and flexors in accordance with the surface anthropometry so far. Therefore, by considering these factors, the objective of the current study is to find out the correlation between femoral length and thigh girth with the knee extensor and flexor muscle performances, determined using an isokinetic dynamometry in young adults. Hence we can suggest when isokinetic strength measurements are performed, these factors also must be considered to have a reliable method of strength measurement.

METHODOLOGY

Participants and Study setting

This is a cross-sectional study, where 18 young, healthy male adults between the ages of 18- 30 years (21.22 ± 1.39) were included. All the study subjects were included from the King Abdul Aziz University, Jeddah, Saudi Arabia. Written signed consent was obtained from all the eligible participants after giving the necessary information regarding the study objectives and procedures. The current study was conducted after obtaining the approval of the Institutional Ethical Committee of Faculty of Applied Medical Sciences (Ref No: KAU/FAMS/PT/2019/19), King Abdul Aziz University, Jeddah.

Inclusion and Exclusion Criteria:

Subjects included in the current study were only those who fulfilled the criteria like; aged between 18 and 30 years old; male participants and those who are willing to provide informed consent. However, the subjects were excluded if they; had a history of any musculoskeletal injury to the leg; are of a professional player in any sort of games or sports; had a diagnosis of any serious medical problem or history of significant lower extremity surgery within the last six months, had any specific diagnosed neuromuscular disease or disorders; and chronic back pain.

Assessment Methods:

All the participants were measured for the anthropometric measurements like height, weight, thigh circumference, and femoral length, following which each one of them was subsequently measured for the isokinetic strength of knee extensors and flexors. These data were compared and correlated for the analysis.

Anthropometric Measurements:

The thigh circumference was measured by making the subject to lie in the position of supine and with an extended knee; the thigh circumference (centimeters to the nearest tenth) was assessed at exactly midway of the measured distance between the greater trochanter and the lateral epicondyle of the femur with use of the same tape measure in all subjects [9]. The femoral length was measured in the same position by an inch tape from the highest point of the greater trochanter to the distalmost point of the lateral femoral condyle, and all the measurements were made to the nearest centimeters [4].

Isokinetic Knee Muscle Strength Measurement:

The isokinetic strength measurements were assessed by using a Biodex System 3 Isokinetic dynamometer (Biodex Medical Systems, Inc., 2000, Shirley, NY, USA) where the concentric knee extensors and flexors effort of the leg that is dominant was tested. The calibration settings of the dynamometer were documented at regular intervals throughout the collection of data according to the guidelines of the manufacturer. The variables collected in isokinetic measurements used for analysis were peak torque at three different angular velocities like; 60°/s, 120°/s, and 180°/s [10, 11].

The subjects were made to sit in the device with an inclination about 85^0 for the backrest of the chair, and by using a chest cross strap, the subjects were kept firmly to the chair. Among the two straps, one placed across the waist and another one across the distal thigh of the knee being tested. The axis of rotation of the dynamometer was aligned with the lateral femoral epicondyle of the tested limb. The dynamometer's lever arm pad was kept against the subject's distal end of the tibia just above the level of medial malleolus without disturbing the ankle movement. The subjects were made to perform the movement at preset angular velocities of 60^0/s, 120°/s, and 180^0/s with three repetitions each through a 60^0 range of motion (ROM 90^0 through 30^0 of knee flexion). The most reproducible and safest method of testing the muscle strength in isokinetic dynamometry is shown to be at 60° per second. Among these, the higher velocities represent muscle endurance, whereas the lower velocities primarily reflect the muscle strength[10, 11, 12, 13].

The subjects were given warming up exercises on a static bicycle for about 5 minutes before starting the testing. The subjects have instructed the operation of the dynamometer and were made to practice five repetitions of extension-flexion concentric knee contractions at 60^0/s at a low effort level for familiarizing the device. The subjects with their maximal effort were then experienced three alternating concentric/ concentric repetitions at three testing velocities. The researcher emphasized to the subjects about the significance of the test to gain the maximal effort. The investigator also explained about maintaining the efforts in the entire ROM, due to which the chances of injury will be relatively small. To provide additional stabilization, the subjects were asked to grasp the side handlebars; this could also maintain good head contact with the chair's headrest. With three minutes of rest, the participants were made to perform three pairs of alternating concentric-concentric maximal repetitions at all the three testing velocities, with a pause for 15 seconds in between the repetitions [10].

STATISTICAL ANALYSIS:

The data were statistically analyzed by using the statistical package SPSS for Windows version 21.0 and Graph Pad version 6. The level of statistical significance was set at $p < 0.05$. The normality of the data was tested with the Pearson normality test and the D'Agostino test. Descriptive statistical analysis and Pearson correlation analysis were performed to determine the anthropometric measurements and knee flexor and extensor strength relationships.

RESULTS

Eighteen male subjects with a mean age of 21.22 ± 1.39 completed the evaluation, among which 13 (72%) of them were right-side dominant, and 05 (28%) of them were left-side dominant. Demographic characteristics, descriptive statistics for anthropometric variables, and all Isokinetic Peak Torque values at three different velocities are mentioned in Table: 1. The results showed the mean femoral lengths of the subjects were 41.94 cms (SD 4.06), and the mean thigh girth was 43.67cms (SD 6.80). The mean isokinetic peak torque at an angular velocity of 60^0/s, 120^0/s, and 180^0/s for knee extensors were 170.4 (SD 37.44), 142.3(SD 28.25) and 118.70 (SD 25.65) respectively. In contrast, the mean isokinetic peak torque at angular velocities of 60^0/s, 120^0/s, and 180^0/s for knee flexors were 80.76 (SD 21.10), 73.26 (SD 21.16) and 66.12 (SD 19.68) respectively.

Table 1: Demographic data and baseline characteristics of participants

	Mean ± SD	95% CI
Age (Years)	21.22 ± 1.39	20.53 - 21.92
Height (cm)	171.6 ± 6.26	168.40 - 174.70
Weight (kg)	74.61 ± 15.26	67.02 - 82.20
Thigh girth (cm)	43.67 ± 6.80	40.29 - 47.05
Femoral Length (cm)	41.94 ± 4.06	39.92 - 43.97
Peak torque 60 quadriceps	170.4 ± 37.44	151.7 - 189.0
Peak torque 120 quadriceps	142.3 ± 28.25	128.3 - 156.4
Peak torque 180 quadriceps	118.7 ± 25.65	105.9 - 131.5
Peak torque 60 hamstrings	80.76 ± 21.10	70.27 - 91.25
Peak torque 120 hamstrings	73.26 ± 21.16	62.74 - 83.78
Peak torque 180 hamstrings	66.12 ± 19.68	56.33 - 75.90

The findings of the Pearson correlation values between the femoral length and the three different isokinetic peak torque at angular velocities for knee extensors were 60^0/s (r= 0.65, p≥ 0.05), 120^0/s (r= 0.31, p≥ 0.05), 180^0/s (r= 0.18, p≤ 0.05). Meanwhile the Pearson correlation values between the femoral length and the three different isokinetic peak torque at angular velocities for knee flexors were, 60^0/s (r= 0.20, p≥ 0.05), 120^0/s (r= 0.24, p≥ 0.05), 180^0/s (r= 0.20, p≥ 0.05). These results show that there is a weak positive correlation between the femoral length and isokinetic peak torque of knee extensors and flexors except a moderate correlation existing for knee extensors at an angular velocity of 60^0/s (Table 2 & Figure 1).

Table 2: Correlation between the femoral length and thigh girth with isokinetic peak torque values of both quadriceps and hamstrings

	Femoral length			Thigh girth		
	r value	95% CI	*P* value	*r* value	95% CI	*P* value
Peak Torque 60^0/s Quadriceps	0.65	-0.02 - 0.75	0.06	0.52	0.07 - 0.79	0.02
Peak Torque 120^0/s quadriceps	0.31	-0.18 - 0.67	0.21	0.69	0.33 - 0.87	0.01
Peak Torque 180^0/s Quadriceps	0.18	-0.31 - 0.60	0.03	0.73	0.41 - 0.89	0.001
Peak Torque 60^0/s Hamstrings	0.20	-0.29 - 0.61	0.42	0.53	0.09 - 0.80	0.02
Peak Torque 120^0/s Hamstrings	0.24	-0.25 - 0.64	0.33	0.24	-0.24 - 0.64	0.32
Peak Torque 180^0/s Hamstrings	0.20	-0.29 - 0.61	0.42	0.44	-0.03 - 0.75	0.06

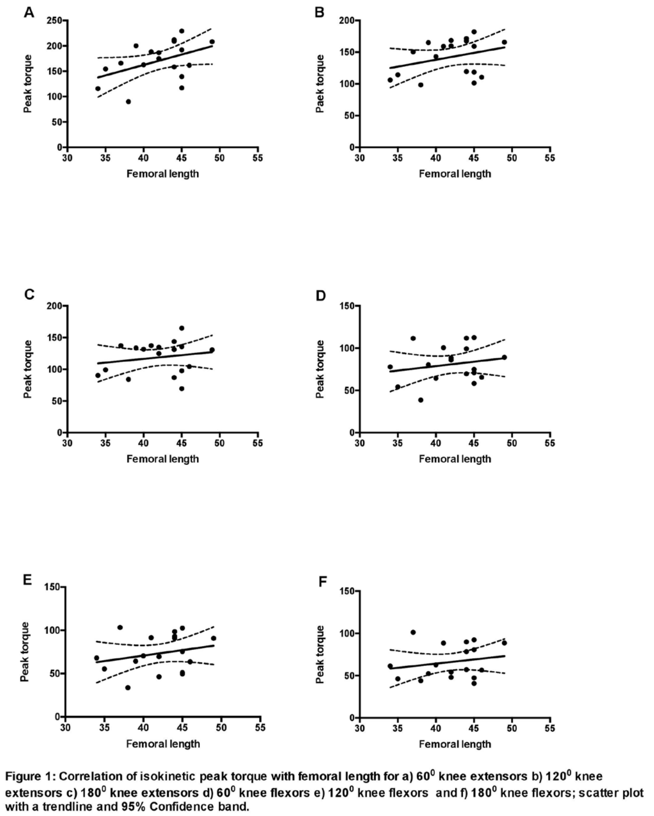
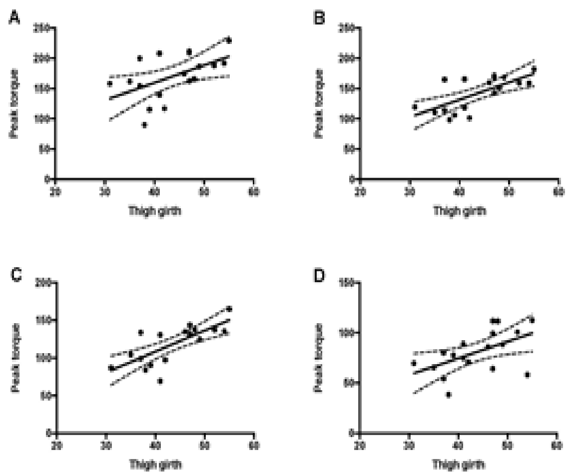


Figure 1: Correlation between the femoral length and knee muscles isokinetic peak torques

The results of the Pearson correlation values between the thigh girth and the 3 different isokinetic peak torque at angular velocities for knee extensors were 60^0/s (r= 0.52, p≤ 0.05), 120^0/s (r= 0.69, p≤ 0.05), 180^0/s (r= 0.73, p≤ 0.05). Whereas the Pearson correlation values between the thigh girth and the 3 different isokinetic peak torque at angular velocities for knee flexors were 60^0/s (r= 0.53, p≤ 0.05), 120^0/s (r= 0.24, p≥ 0.05), 180^0/s (r= 0.44, p≥ 0.05). The findings show that there is a moderate to high positive significant correlation exists between the thigh girth and the isokinetic peak torque of flexors and extensors of the knee, except a weak correlation shows for knee flexors at an angular velocity of 120^0/s **(Table 2 & Figure 2).**



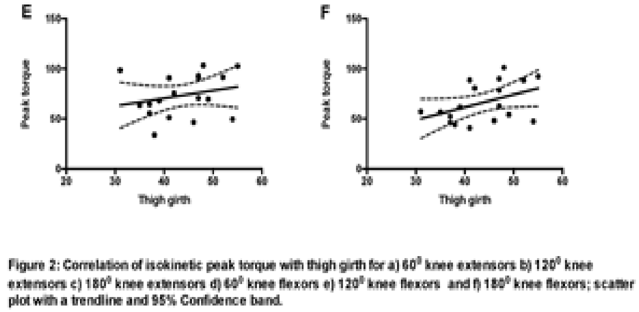


Figure 2: Correlation between the thigh girth and knee muscles isokinetic peak torques

DISCUSSION

The main purpose of the current study was to find out and understand the correlation between the anthropometric measurements like; femoral length and thigh girth with knee flexor and extensor muscles performance determined with the use of an isokinetic dynamometer in healthy young adults. We have recruited 18 normal young male, healthy subjects aged between 18 to 30 years for this study. In the current study, the participants were only male subjects because, the study by Stephanie J. Bowerman et al. (2006) [14] proved that, there is a difference exists in the isokinetic muscle strength between the genders and this may have an impact on the results of the study. Nevertheless, it was also included only the young age group of 18 to 30 years old subjects to avoid any age factor bias which may alter the values. Apart from that, we have considered only the dominant side data for the analysis to standardize the calculation.

In the present study, we have recorded the isokinetic peak torque of extensors and flexors of the knee to analyze muscle strength. For an objective measure of the muscle strength following any knee joint surgeries, the isokinetic and isometric modes are a reliable source and which has been used in the clinical setup for many years. The most reproducible and safest method of muscle strength testing can be performed by isokinetic dynamometry is at 60° per second [13]. The muscle strength can be quantitatively measured with isokinetic dynamometry, where the joint position, the resistance, and the velocity are controlled tightly. The sensitivity and reliability for knee and ankle testing by isokinetic dynamometry have shown to be good in people who have musculoskeletal disorders [5].

The results of the current study show a mean isokinetic peak torque value at angular velocities of 60^0/s, 120^0/s, and 180^0/s for knee extensors as 170.4, 142.3, and 118.70 respectively, whereas the mean isokinetic peak torque values at same angular velocities for knee flexors were 80.76, 73.26 and 66.12 respectively. These values are inversely proportional to the respective angular velocities which are chosen. And it can be understood from these values that, as the velocity reduces, the torque produced is high where the subject has to put maximum effort to counteract the resistance offered by the device. In further, it is found that the subjects who participated in the current study have shown a better performance of peak torque production for both flexors and extensors of knee. Based on the Biodex System 3 Isokinetic dynamometer reference values of normative data for these muscles, subjects who participated in this study were performed well, and all the values were almost double than that of the values prescribed by the manufacturer.

The results of the correlation findings show that there is a weak positive correlation between the femoral length and knee muscles isokinetic peak torque values at all three angular velocities except a moderate correlation existing for knee extensors at an angular velocity of 60^0/s. The study results of Tsaopoulos et al. (2007) [15] and O'Brien et al. (2009) [4], are in agreement with our study findings, in which they stated that even though there is a relationship between the muscle strength and body anthropometrics exists in adults in some areas of the body, such a relationship could not be shown for the knee musculature. Ultimately it can be stated that the femoral length may not play a significant role in altering the strength of the muscles.

The other significant finding of the current study is that there is moderate to high positive significant correlation existing between the thigh girth and the isokinetic peak torque of flexors and extensors of the knee at all three angular velocities except a weak correlation existing for knee flexors at an angular velocity of 120^0/s. This reveals that, as the thigh girth increases, the performance of the knee flexors and extensors also increases, which in turn can be stated as the girth of the extremity reflects on the muscle performance. However, the role of the body fat content must be taken into consideration when this principle is applied to the obese subjects because, according to F. Rastelli et al. (2015) [16], higher muscle tissue fat content can have a negative effect on muscle performance during isokinetic muscle contractions. The current study findings also supported by the other studies by C.M. Waugh et al. (2011) [3], where they stated that gains in muscular strength are in proportion to the increase in muscle size and change in muscle architecture. This finding is also confirmed by the study of O'Brien et al. (2009) [4], where they have explained that their size largely influences muscle strength. The statement by the authors, Bazett-Jones (2011) [17], describes that the size of the region strongly influences muscle strength. However, to study the specific features about the muscle groups and to isolate the muscle tissues, some of the following advanced methods need to be adopted. To find out the muscle fiber characterization, the use of muscle biopsy, for the estimation of total muscle mass, the stereological MRI techniques, and to understand the cross-sectional area of muscles, the use of computer tomography or ultrasound scanning is advisable [8].

The methodology and the protocol we followed were similar to the previous studies to make it more standardized. The isokinetic variables selected for analysis were peak torque at three different angular velocities of; 60°/s, 120°/s, and 180°/s, as these velocities have shown to be the most reproducible and safest method in the isokinetic evaluation. Higher velocities are meant for depicting the muscle endurance, whereas, the lower velocities are primarily to detect the muscle strength [10, 13].

Hence, with the findings of this study, we can suggest that when isokinetic strength measurements are performed, these factors also must be taken into consideration to have a better reliable method of strength assessment. The importance of the current study is especially useful while comparing different body physique persons or protocols where the measurements of anthropometric values could change between data collection periods. Normalization of strength measurement values to different body size subjects have been used in the clinical assessment to remove the dependency of various body-sizes. However, the method to be adopted for the normalization of strength measurements is of no consensus so far. There were some limitations for our study, which includes; an only dominant leg has been taken into consideration, and no comparisons were made between dominant and nondominant side. The number of subjects for this study was only 18 individuals, which is relatively a minimal sample size, and this was conducted only in males with the age group between 18-30 years. So the findings of the study cannot be generalized across the different age groups. Further research can be done involving both genders, and a comparison can be made between male and female populations, even in different age groups, to look for the variations.

CONCLUSION

In conclusion, the result of the current study shows that there is a moderate to strong positive correlation existing between the thigh girth and the isokinetic peak torque of knee flexors and extensors. Moreover, there is only a weak positive correlation exists between the femoral length and the isokinetic peak torque of flexors and extensors of knee. So it reveals that the length of the extremity does not seem to influence the outcome of isokinetic measurement values. In contrast, the girth of the muscle can influence the outcome of the isokinetic measurement values, especially for the knee joint.

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