HAMSTRING AND QUADRICEPS STRENGTH RATIO: Effect of Age and Gender

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SUMMARY

This study was carried out to investigate how age and gender influence hamstring-quadriceps (knee flexor-extensor) muscle strength ratio in a Nigerian urban population. One hundred and fifty apprently healthy male and female subjects in 3 age groups (group I, 11-20 years; group II, 21-40 years and group III, 41-60 years) participated. The hamstrings and quadriceps isometric muscle strength of all the patients was measured and their ages were recorded. The hamstring-quadriceps strength ratio for each subject was also calculated.

The results showed that the hamstring muscles of the subjects have a strength that is about half the strength of the ipsilateral quadriceps femoris muscle in each of the groups. A comparison of hamstring-quadriceps muscle strength ratio across the age groups releaved no significant difference among both male and female subjects ($p > 0.05$). No significant gender difference was found among the subjects in the age groups 11-20 years and 41-60 years ($p > 0.05$) but in the age group 21-40 years the male subjects had a significantly higher Hamstring-Quadriceps strength ratio than their female counterparts ($p < 0.05$).

It was concluded that age has no effect on hamstring/quadriceps (knee flexor/extensor) strength ratio, whether in female or male individuals, and that male and female variation is related to a sense of competitiveness, societal achievement expectation and propensity to display prowess.

Key words: muscular strength, hamstring/quadriceps strength ratio, age and sex

INTRODUCTION

Muscles play a major part in adjusting the body to environmental changes, which may include the purposeful movement of the whole body from one point in space to another, or the movement of a limited part of the body in respect to the body itself, or to the environment.[1] Muscle strength has been defined as the capacity of a muscle to produce the tension necessary for the maintenance of posture, initiation of movement or control of movement during a condition of loading on the musculoskeletal system.[2]

The assessment of physical strength is often of interest in epidemiological investigations. Strength measurement is used to find out the relationship between strength and the maintenance of health status. It has been documented that the peak torques of the quadriceps are greater than those of the hamstrings though there is no particular strength ratio that is appropriate for all categories of people in a population. It has also been documented that knee flexor-extensor ratio may vary depending on angular velocity, population tested, measuring equipment, age, test position, gender, total body weight, and the type of activity the subjects are involved in.

Depending on the type of contraction adopted, muscle strength can be said to be isotonic, isokinetic or isometric. Isometric strength, which is the focus in this study, is defined as the tension generated in a muscle when the muscle is contracting without any apparent change in length.[1] Studies by Lehminkuhl and Smith found that the peak torques for the quadriceps are greater than those of the hamstring muscles. This is because anatomically, the knee extensors have over twice the cross-sectional area of the knee flexors, and the knee extensors have a longer force arm distance than the flexors. Balance in the strength of extensors and flexors of the knee joint are important for functional usage of the knee in various activities, hence the need to know the ratio of these two groups of muscles could not be

overemphasized. Normal knee flexor-extensor ratio had been reported to vary between 0.4 and 0.9.[3,4,5] It has been generally assumed that without any doubt, the hamstring and quadriceps femoris muscle strength ratio vary with gender and from population to population.[6] There is, therefore, a need to investigate the maximal isometric flexor-extensor strength ratio in normal male and female subjects in this environment.

MATERIALS AND METHODS

Subjects

One hundred and fifty (150) apparently healthy subjects participated in this study. The sample population was divided into 3 groups according to their ages. These were 60 subjects (30 males and 30 females) in each of groups I (age 11-20 years) and II (age 21-40 years), however group III (age 41-60 years) had only 30 subjects (15 males and 15 females). Informed consent of each participant was sought and obtained after the testing procedure was explained in line with ethical guidelines. The subjects were also informed of their right to withdraw if they so wished at any point in the course of the study.

Procedure

The blood pressure of each subject was taken and recorded to exclude the subjects with hypertension. Each subject performed one practice session of three sub-maximal knee flexion and extension and rested for a minimum of 5 minutes before actual measurements were taken. Two (2) trials each of flexion and extension of the knee joint were carried out with a ten-minute rest in between flexion and extension contractions to prevent or minimize the influence of fatigue on the measurement.

The method described by Murray et al.[7] was followed. The Salter model of scale balance was adapted as a tensiometer to measure the isometric quadriceps and hamstring muscle strengths.

Data Analysis

The mean and standard deviation of the variables of age, weight, height, maximal isometric knee extensor (quadriceps) strength, maximal isometric knee flexor (hamstring) strength, and hamstrings-quadriceps strength ratio were calculated.

The independent t-test was used to compare all the variables between the male and female subjects while the one-way analysis of variance (ANOVA) was used to compare the variables across the three age groups. Where ANOVA indicated significant across-group difference, the Scheffe's post hoc analysis was used to ascertain which pair(s) of groups differed significantly.

The Pearson's product-moment correlation method was used to investigate the relationship between each variable of height (Ht) and weight (Wt) and the following variables: maximal isometric quadriceps strength (MQS), maximal isometric hamstrings strength (MHS) and hamstrings-quadriceps strength ratio (H/QR).

RESULTS

The mean muscle strengths (MQS and MHS) and the standard deviation of the muscle strengths across the three groups, for male and female subjects are recorded in table 1. The values were compared across the three groups. The calculated F-values for male and female subjects are recorded in table 2. The MQS and MHS differed significantly across the age groups. The Scheffe post-hoc test revealed that for both male and female subjects, the MQS for group I subjects (39.7 kg) was significantly less ($P<0.05$) than for group II (54.2 kg) and group III (49.6 kg). The values for groups II and III were not significantly different ($P > 0.05$). The MHS of the male subjects in group I (23.1 kg) was also significantly less ($P < 0.05$) than those male subjects in group II (31.5 kg). No significant across-group difference was observed in the H/QR among the male as well as the female subjects ($P > 0.05$).

The gender effect on MQS, MHS and H/QR was tested using the independent t-test. Results are summarized in table 3. The male subjects had significantly higher muscle strength (MQS and MHS) values ($P < 0.005$) than the female subjects in all the age groups. A significant gender effect on the H/QR was found only in the subjects in group II. The male subjects had a higher ($P < 0.05$) value (58.0) than the female subjects (52.8).

The relationship between the physical characteristics (Ht and Wt) of the subjects and each of the muscle strengths (MQS and MHS) and H/QR were studied using the Pearson product-moment correlation method. The correlation coefficient ® values obtained are recorded in table 4.

Table 1. Subjects' Quadriceps and Hamstring Muscle Strengths and Hamstring-Quadriceps Strength Ratio

Physical Characteristics		Group I (11-20 years)		Group II (21-40 years)		Group III (41 - 60 years)	
		Male	Female	Male	Female	Male	Female
Age (Yrs)	**Mean**	**16.97**	**15.43**	**25.77**	**24.53**	**47.33**	**48.20**
	S.D.	2.76	3.42	5.14	4.41	5.33	6.11
Wt (Kg)	**Mean**	**51.77**	**43.97**	**63.83**	**57.87**	**67.47**	**64.00**
	S.D.	12.77	12.96	9.54	8.66	10.56	15.06
Ht (m)	**Mean**	**1.64**	**1.53**	**1.76**	**1.65**	**1.76**	**1.62**
	S.D.	0.13	0.13	0.07	0.05	0.08	0.06
Muscle Strength (kg)							
MQS	**Mean**	**39.7**	**28.13**	**54.2**	**35.97**	**49.6**	**33.40**
	S.D.	15.51	9.07	11.33	7.94	13.72	9.11
MHS	**Mean**	**23.13**	**15.3**	**31.5**	**19.07**	**27.67**	**18.20**
	S.D.	9.15	5.02	7.49	5.32	6.48	5.17
Strength Ratio (%)							
H/QR	**Mean**	**59.17**	**54.83**	**58.03**	**52.83**	**57.07**	**55.33**
	S.D.	11.07	13.3	6.23	9.93	9.85	7.04

Table 2. Results of Post hoc analysis of Effect of Age on Quadriceps and Hamstring Muscle Strengths and Hamstring-Quadriceps Strength Ratio

	Mean Muscle Strength				
	Group I 11-20 yrs	Group II 21-40 yrs	Group III 41-60 yrs	Calculated F	p-value
Male					
QS (Kg)	39.7	54.2	49.6	8.783*	0.000
				8.161*	0.001
HS (Kg)	23.13	31.5	27.67		
H/Q Ratio (%)	59.17	58.03	57.07	0.283	0.754
Female					
QS (kg)	28.13	35.97	33.4	6.31*	0.003
HS (kg)				4.21*	0.02
	15.3	19.07	18.2		
H/Q Ratio (%)	54.83	52.83	55.33	0.393	0.677

Horizontal lines join pairs of values that are significantly different ($P < 0.05$)

Table 3. Comparison of male and female Quadriceps, Hamstring Muscle Strengths and Hamstring-Quadriceps Strength Ratio

		Group I (11 - 20 Yrs)	Group II (21 - 40 Yrs)	Group III (41 - 60 Yrs)
Quadriceps Strength (QS)	Calculated t	3.526*	7.218*	3.811*
	p-value	0.001	0	0.001
Hamstrings strength (HS)	Calculated t	4.113*	7.416*	4.424*
	p-value	0	0	0.000
Hamstrings-Quadriceps strength ratio (H/QR)	Calculated t	1.372	2.430*	0.490
	p-value	0.175	0.018	0.628

*Indicates significant gender difference $p<0.05$.

Table 4. Relationship between Subjects' Physical Characteristics and Muscle Strength

	Correlation Coefficient ®					
	Group I (11 - 20 yrs)		Group II (21 - 40 yrs)		Group III (41 - 60 yrs)	
	Male	Female	Male	Female	Male	Female
HEIGHT						
QS	0.67	0.612	0.176	-0.129	0.447	0.172
HS	0.551	0.553	0.294	-0.023	0.082	-0.308
H/Q Ratio	-0.124	-0.097	0.265	-0.255	-0.472	-0.429
WEIGHT						
HQ	0.847	0.683	-0.643	-0.035	0.443	0.2
HS	0.701	0.64	-0.67	-0.162	0.157	-0.357
H/Q Ratio	-0.19	-0.066	0.183	-0.281	-0.468	0.187

The heights of the subjects were poorly correlated with the strength variables, both for male ® = 0.082) and female ® =0.023) subjects. For body weight, a good correlation was found between weight and MQS among male subjects in group I ® = 0.847), while there was a fair correlation with MHS ® = 0.701). From the values recorded in table 4, it can be observed that the relationship between weight and muscle strength (MQS and MHS) as well as between height and muscle strength is higher in the group I subjects (male as well as female). The relationship between each of weight and height and the H/QR is generally poor ® = 0.066–0.472).

DISCUSSION

Quadriceps and hamstring muscle strength (MQS and MHS) differed significantly across the three age groups. Group I subjects had significantly lower strength than subjects in groups II and III, but groups II and III subjects had similar values for male and female subjects. This is in agreement with previous reports that age affects muscle strength. It had been reported that individuals attain peak muscle strength in the third decade of life (between the ages of 20 and 30 years) after which the strength begins to decline gradually so that the strength of a person of 65 years is approximately 80% of that attained between the ages of 20 and 30 years.[8,9] This decline in strength with advancing age has been attributed to a reduction in the number of motor neurons and therefore a decline in muscle mass.[8,10] The actual values of the MQS for example, (54.2 kg for group II and 49.6 kg for group III among the males; 35.97 kg for group II and 33.4 kg for group III among the females) reveal such a decline even though insignificant. The group III subjects (41-60 years) had a minimal decline in muscle strength when compared to group II subjects (21-40 years). The muscle strength values among the group III subjects ranged between 87.8% and 95.4% of the muscle strength values for the group II subjects.

A significant gender difference was observed in the MQS and MHS across the three groups. Male subjects had significantly higher muscle strength in all the age groups. This is in agreement with the literature. It has been documented[11] that men generally have muscular strength values almost twice as high as that of women. In this study, women had 61% - 71% of that of the men with an average of 66.2%, almost two-thirds (2/3) that of the men.

The hamstring-quadriceps muscle strength ratio for the subjects varied between 57.067 and 59.167 for the male subjects and between 52.833 and 55.333 for their female counterparts. These values are in line with those reported in the literature.[3,4,5] A comparison of these values across the age groups revealed no significant difference. This suggests a similar trend in the strength of the two muscles (hamstring and quadriceps) with age.

There is a generally poor relationship between physical characteristics and muscle strength (MQS and MHS) as well as H/QR contrary to previous reports.[3,4] The only exemptions were the relationships between weight and MHS (fair, r = 0.701) and MQS strength (good, r = 0.847) in group I male subjects.

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