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Original Research Article

Comparison of Ratio of Isometric Strength in Hamstring and Quadriceps at Different Knee Angles in Normal Healthy Individuals of Age Group 20-40 Years

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ABSTRACT

The main purpose of this study is to find out the ratio of maximum isometric tension of quadriceps and hamstring at different angles of knee flexion, (30^0,45^0,60^0) with hip position in neutral and to find out the difference between maximum isometric tension of quadriceps and hamstrings in the dominant and non-dominant side. Study design was Cross sectional study with convenience sampling. The research setting was done at the Physiotherapy Department in All India Institute of Physical Medicine & Rehabilitation. Participants for this study include 50 healthy individual with 25 males and 25 females. The main outcome measures is Isometric strength was measured at different angles. Each measurement was repeated thrice and average was taken .then in dominant and non dominant sides were measured one side after other. Result shows that there was no significant difference between the dominant and non dominant limb strength of Quadriceps and hamstring in both male and females ($p>0.05$).The maximum isometric tension of Quadriceps is highest at 60^0 knee flexion ($p<0.05$) when compared to 30^0 and 45^0. The maximum isometric tension of hamstring is highest at 30^0 knee flexion ($p<0.01$) when compared to 45^0 and 60^0.

Key words: *Maximum isometric tension, spring balance, Hip position in neutral.*

INTRODUCTION

Background

Like many other human capabilities, muscle strength is a complex phenomenon to characterize because of its wide range of normal variability and the fact that strength is affected by many factors such as sex, age, test position and type of contraction [(1)] Muscle strength is the greatest measurable force that can exerted by a muscle or muscle group to overcome resistance during single maximal effort. [(2)]

In rehabilitation the type of muscle contraction plays a vital role in improving muscle strength. The 3 types of muscle contraction currently available are isometric, isotonic and isokinetic.

Theoretically in isometric contraction in which relatively small amount of fiber shortening occur and there is a sufficient time for the maximum number of cross bridges to form, thus allowing maximal tension to develops. [(1)]

The relation between torque exerted by a muscle group and joint angle is too useful in clinical setting and human factors engineering. The relationship between torque and bony segment position (joint angles) is determined by 3 factors such as Cross sectional area of the muscle, Length

tension relationship of muscle, Mechanical characteristic of lever system. The greater the cross sectional area, greater the contractile protein, and consequently the more force that can be developed. [(3)]

Knee is the largest and most complex joint of the body. Knee is the most frequently injured area of the body mainly in sports activities. Knee pathology is mostly associated with higher muscle imbalance between hamstring and quadriceps muscle groups.

Hamstring and quadriceps (H: Q) strength ratio has been used to examine the similarity between the hamstring and quadriceps, to asses knee functional ability and muscle imbalance. It has been suggested that a highly developed quadriceps muscle contribute to decreased antagonist co activation, thereby increasing susceptibility of anterior cruciate ligament injury.

Patricia Murray et al (1980) studied the isometric knee strength of quadriceps and hamstring at different angles (30^0,45^0,60^0) at different age groups, but there studies were limited to a hip joint position 90 degrees. [(1)]

In earlier studies, Lunnen et al (1981), examined isometric hamstring torque values only at 60^0 of knee flexion and hip position at (0^0,45^0,90^0 and 135^0) of flexion and found that isometric hamstring torque values are less at 0 degrees than 90^0 and 135^0 hip flexion. [(4)]

Currier et al (1977) who examined greater quadriceps force production at 60^0 of knee flexion from hip position between various angles and maximum was between110^0 to 130^0. [(5)]

The main purpose of this study is to find out the ratio of maximum isometric tension of quadriceps and hamstring at different angles of knee flexion, (30^0,45^0,60^0) with hip position in neutral and to find out the difference between maximum isometric tension of quadriceps and hamstrings in the dominant and non-dominant side.

MATERIALS AND METHODS

Research design: This study was a cross sectional study with convenience sampling.

Subjects: Participants for this study include 50 healthy individual with 25 males and 25 females.

Selection of criteria: Inclusion criteria were Individuals aged between 20 to 40 years, Q angle ranging between 10^0 to 18^0 (where Q angle for males is 13^0 and females is 18^0) and Normal gait, on observational analysis.

Exclusion criteria were any pain in the lower extremity and spine, Musculoskeletal or neurological involvement in bilateral lower limbs, Limb length discrepancy, No deformities in spine (i.e. lumbar scoliosis), hips, knee and ankle, Any history of surgery in the lower extremity, Underweight or obese and Subject who are sports person/ involved with physical fitness programme. Apparatus include Spring balance calibrated in Kilo Grams (0-100 kgs), Goniometer, Testing table and small stool, Pelvic sling (35 inch) with rope and ankle strap, Ropes with 3 marking, Towel rolls, Bathroom scale and the inch tape.

Figure 1: Apparatus used in this study

Procedure

Written consent was obtained from the subjects who met the selection criteria and were included in this study. After obtaining informed consent, the participants were tested individually. The research setting was done at the Physiotherapy Department in All India Institute of Physical Medicine & Rehabilitation (AIIPMR). Prior

to the procedure the following assessment was carried out. The subject was instructed to kick a ball kept in front of him. The leg with which he kicked was noted and it was repeated once again to ascertain the dominant leg. [(6)] Thereafter limb length is measured in standing position. (From ASIS to Medial Malleoli).

Warm up: static stretch of quadriceps and hamstring followed by cycling for 10 mins. The tension generated by isometric contraction was measured with spring balance to asses both side knee flexor and extensor musculature. Spring balance scale is a simple and reliable method of measurement of muscle strength. Spring balance works on basis of Hookes principle. Robert Hookes (17^{th} century scientist) states that the ratio for given substance of a given type of stress and strain is constant. [(7)]

Rest period of 90 seconds were taken between consecutive isometric contractions of same muscle group. Reliability of spring balance was established with test and retest method among 10 subjects and't' test were carried out. Pretension and post tension measurement for quadriceps is measured by doing pilot study which was approximately 20^0. Pre and post tension measurement of hamstring were approximately 10^0.

Maximum Isometric Quadriceps Strength

Testing quadriceps strength, the subject lying in supine position with knee flexed to 90^0 with leg hanging at the edge of testing table. A towel roll was kept under lower end of thigh to keep femur horizontal. A towel was kept under lumbar region to maintain lardotic curve. An ankle strap is tied around the ankle in figure of 8 manner and hook of spring balance is attached to it and other end of spring balance was attach to the bar of the testing table.

Each subject is shown about the position and movement to be done. The subject is given instruction to extend "maximally" at shout of "pull".

For measuring quadriceps maximal isometric tension at 60^0 knee flexion, the pretension angle was marked in the rope which should correspond to the knee angle of 80^0 flexion and it was tied to the testing table which was connected with spring balance and other end of apparatus hook was attached to subject ankle with ankle strap. A towel was placed under the lower end of thigh to keep in horizontal position. Now once again measure with Goniometer where the knee flexion angle should be at 80^0 and post tension angle after the forceful extension of knee which should be approximately 60^0. Now note down the tension with help of pointer in apparatus. It was repeated thrice and average was taken. For measuring quadriceps maximal isometric tension at 45^0 knee flexion, the pretension angle was marked in the rope which should correspond to the knee angle of 65^0 flexion and it was tied to the testing table which was connected with spring balance and other end of apparatus hook was attached to subject ankle with ankle strap. A towel was placed under the lower end of thigh to keep in horizontal position.

Now once again measure with Goniometer where the knee flexion angle should be at 65^0 and post tension angle after the forceful extension of knee which should be approximately 45^0. Now note down the tension with help of pointer in apparatus. It was repeated thrice and average was taken.

Figure 2: Maximum Isometric Quadriceps Strength Testing

For measuring quadriceps maximal isometric tension at 30^0 knee flexion, the pretension angle was marked in the rope which should correspond to the knee angle of 50^0 flexion and it was tied to the testing

table which was connected with spring balance and other end of apparatus hook was attached to subject ankle with ankle strap. A towel was placed under the lower end of thigh to keep in horizontal position.

Now once again measure with Goniometer where the knee flexion angle should be at 50^0 and post tension angle after the forceful extension of knee which should be approximately30^0. Now note down the tension with help of pointer in apparatus. It was repeated thrice and average was taken.

Maximum Isometric Hamstring Strength

Testing hamstring strength, the subject lying in prone position with knee extended beyond the edge of testing table and broad sling tied around the pelvis to avoid hip flexion. A towel roll was kept under lower end of thigh for comfort and it was ensured thigh is horizontal.

For measuring hamstring maximal isometric tension at 60^0 knee flexion, the pretension angle was marked in the rope which should correspond to the knee angle of 50^0 flexion and it was tied to the testing table which was connected with spring balance and other end of apparatus hook was attached to subject ankle with ankle strap. A towel was placed under the lower end of thigh for comport.

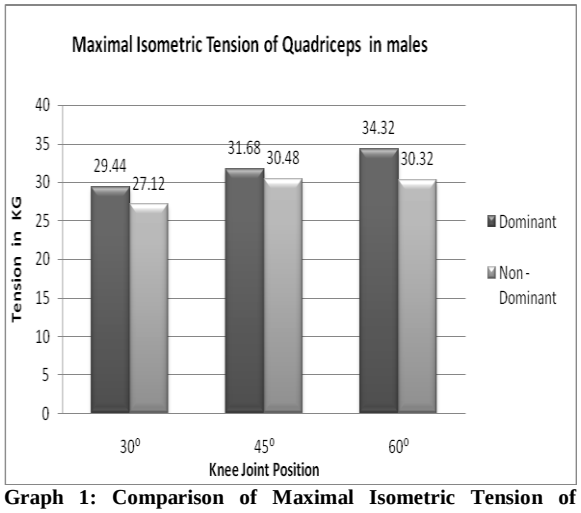
Now once again measure with Goniometer where the knee flexion angle should be at 50^0 and post tension angle after the forceful extension of knee which should be approximately60^0. Now note down the tension with help of pointer in apparatus. It was repeated thrice and average was taken. For measuring hamstring maximal isometric tension at 45^0 knee flexion, the pretension angle was marked in the rope which should correspond to the knee angle of 35^0 flexion and it was tied to the testing table which was connected with spring balance and other end of apparatus hook was attached to subject ankle with ankle strap. A towel was placed under the lower end of thigh for comport. Now once again measure with Goniometer where the knee flexion angle should be at 35^0 and post tension angle after the forceful extension of knee which should be approximately 45^0. Now note down the tension with help of pointer in apparatus. It was repeated thrice and average was taken.

For measuring hamstring maximal isometric tension at 30^0 knee flexion, the pretension angle was marked in the rope which should correspond to the knee angle of 20^0 flexion and it was tied to the testing table which was connected with spring balance and other end of apparatus hook was attached to subject ankle with ankle strap. A towel was placed under the lower end of thigh for comfort. Now once again measure with Goniometer where the knee flexion angle should be at 20^0 and post tension angle after the forceful extension of knee which should be approximately30^0. Now note down the tension with help of pointer in apparatus. It was repeated thrice and average was taken. The quadriceps and hamstring strength of both limbs were measured one after the other. Data obtained was used for statistical analysis.

Figure 3: Maximum Isometric Hamstring Strength Testing

Table 1: Comparison of Maximal Isometric Tension of Quadriceps in Dominant and Non Dominant Lower Extremity at 30^0,45^0 and 60^0 of knee Flexion in Males

Si No	Angle	Dominance	N	Mean ± SD(kg)	't' Value	'p' Value
1	30^0	Dominant	25	29.44 ± 6.3	1.405	p>0.05
		Non-Dominant	25	27.12 ± 5.3		
2	45^0	Dominant	25	31.68 ± 8.4	0.513	p>0.05
		Non-Dominant	25	30.48 ± 8.0		
3	60^0	Dominant	25	34.32 ± 7.9	0.669	p>0.05
		Non-Dominant	25	30.32 ± 7.2		



Graph 1: Comparison of Maximal Isometric Tension of quadriceps in Dominant and Non Dominant Lower Extremity at 30^0, 45^0 and 60^0 of Knee Flexion in Males.

Statistical Analysis

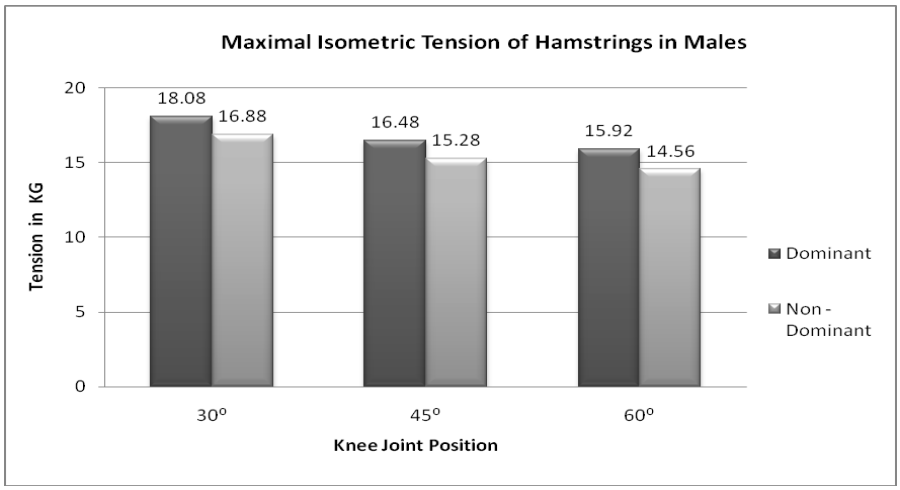
In this study, there were 2 main groups. Group A considered of 25 subjects and group B considered of 25 females. The maximal isometric tension of quadriceps and hamstring was assessed at 3 different angles i.e. 30^0 of knee flexion, 45^0 of knee flexion and 60^0 of knee flexion with hip in neutral position in both dominant and non dominant side.

Unpaired t-test was performed to see if there was significant difference between the dominance and non-dominance of lower extremity in both males and females.

The alternative hypothesis of this study states that there is a significant difference in the ratio of maximal isometric tension of quadriceps and hamstrings at different angles of knee flexion, (30^0,45^0,60^0) with hip position in neutral.

Table 2: Comparison of Maximal Isometric Tension of Hamstrings in Dominant and Non Dominant Lower Extremity at 30^0,45^0 and 60^0 of knee Flexion in Males.

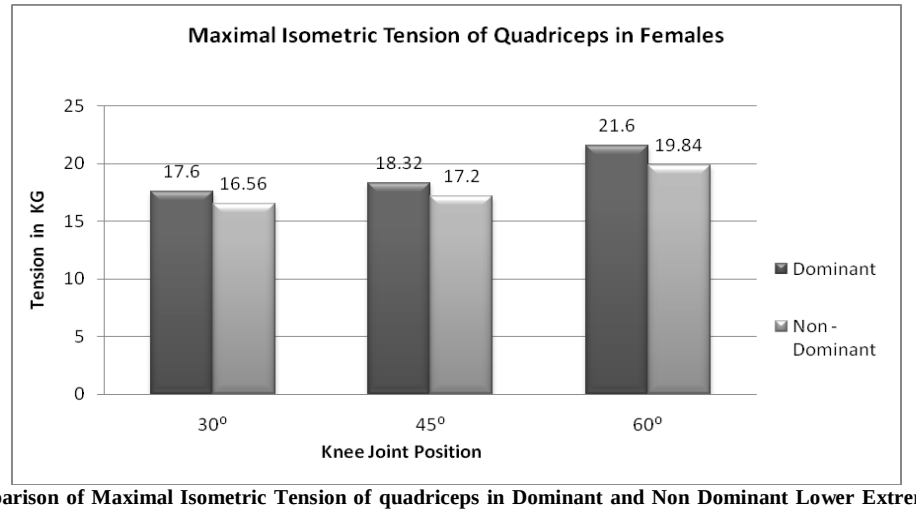
Si No	Angle	Dominance	N	Mean ± SD(kg)	't' Value	'p' Value
1	30^0	Dominant	25	18.08 ± 4.3	1.052	p>0.05
		Non-Dominant	25	16.88 ± 3.7		
2	45^0	Dominant	25	16.48 ± 3.1	1.304	p>0.05
		Non-Dominant	25	15.28 ± 3.4		
3	60^0	Dominant	25	15.92 ± 3.2	1.434	p>0.05
		Non-Dominant	25	14.56 ± 3.5		



Graph 2: Comparison of Maximal Isometric Tension of Hamstrings in Dominant and Non Dominant Lower Extremity at 30^0, 45^0 and 60^0 of Knee Flexion in Males.

Table 3: Comparison of Maximal Isometric Tension of Quadriceps in Dominant and Non Dominant Lower Extremity at 30^0,45^0 and 60^0 of knee Flexion in Females

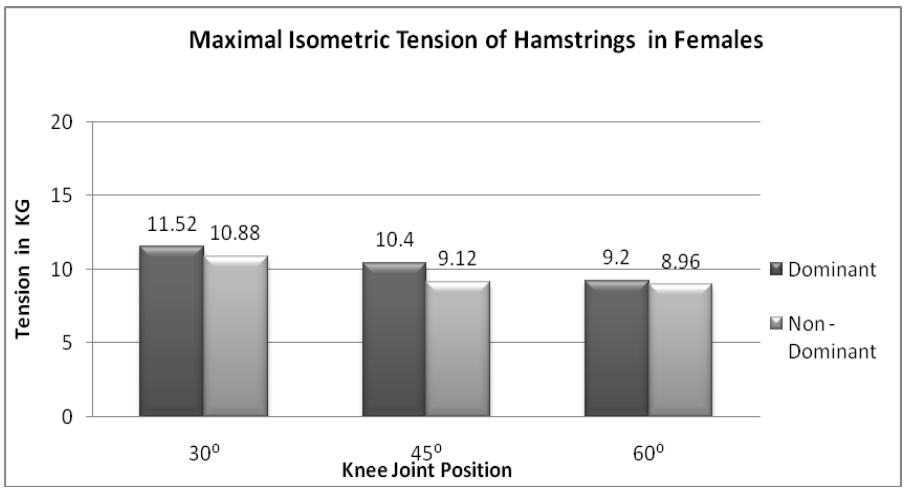
Si No	Angle	Dominance	N	Mean ± SD(kg)	't' Value	'p' Value
1	30^0	Dominant	25	17.60 ± 2.8	1.220	p>0.05
		Non-Dominant	25	16.56 ± 3.3		
2	45^0	Dominant	25	18.32 ± 3.4	1.098	p>0.05
		Non-Dominant	25	17.20 ± 3.8		
3	60^0	Dominant	25	21.60 ± 4.0	1.556	p>0.05
		Non-Dominant	25	19.84 ± 4.1		



Graph 3: Comparison of Maximal Isometric Tension of quadriceps in Dominant and Non Dominant Lower Extremity at 30^0, 45^0 and 60^0 of Knee Flexion in Females.

Table 4: Comparison of Maximal Isometric Tension of Hamstrings in Dominant and Non Dominant Lower Extremity at 30^0,45^0 and 60^0 of knee Flexion in Females.

Si No	Angle	Dominance	N	Mean ± SD(kg)	't' Value	'p' Value
1	30^0	Dominant	25	11.52 ± 3.0	0.823	p>0.05
		Non-Dominant	25	10.88 ± 2.4		
2	45^0	Dominant	25	10.40 ± 2.9	1.669	p>0.05
		Non-Dominant	25	9.12 ± 2.4		
3	60^0	Dominant	25	9.20 ± 2.2	0.3726	p>0.05
		Non-Dominant	25	8.96 ± 2.3		



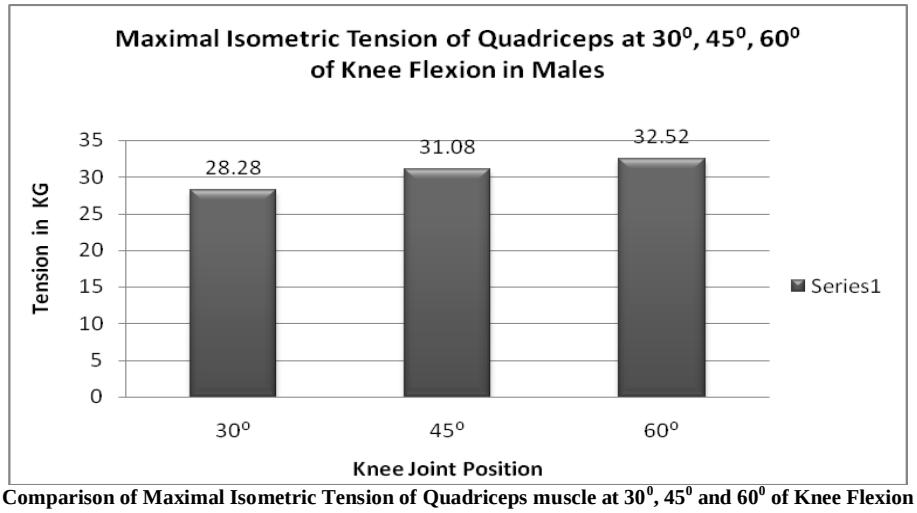
Graph 4: Comparison of Maximal Isometric Tension of Hamstringss in Dominant and Non Dominant Lower Extremity at 30^0, 45^0 and 60^0 of Knee Flexion in Females.

Table 5: Comparison of Maximal Isometric Tension of Quadriceps muscle at 30^0, 45^0 and 60^0 of knee flexion in males

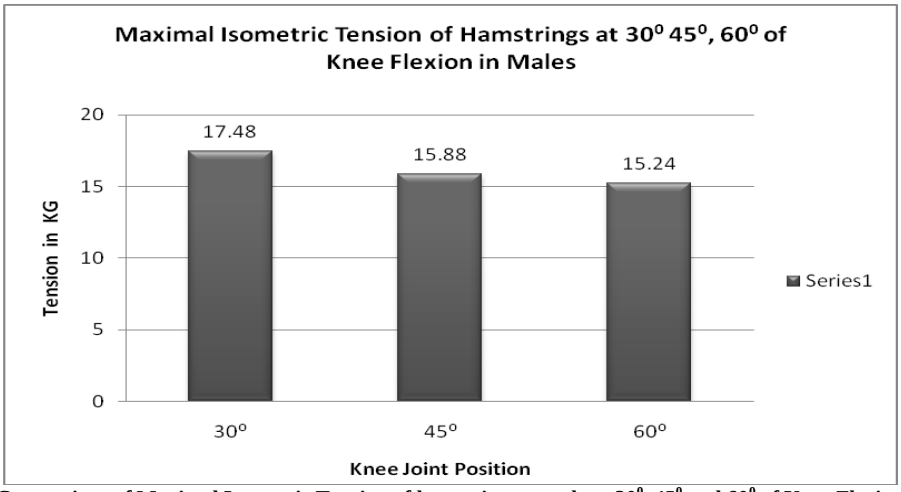
Si No	Groups	Mean	SD	Q Value	P Value
1	30 deg	28.280	5.897	2.721	P>0.05 N/S
	45 deg	31.080	8.204		
2	30 deg	28.280	5.897	4.120	P<0.05
	60 deg	32.520	7.536		
3	45 deg	31.080	8.204	1.399	P>0.05 N/S
	60 deg	32.520	7.536		

Table 6: Comparison of Maximal Isometric Tension of hamstring muscle at 30^0, 45^0 and 60^0 of knee flexion in males

Si No	Groups	Mean	SD	Q Value	P Value
1	30 deg	17.480	4.037	3.143	P>0.05 N/S
	45 deg	15.880	3.317		
2	30 deg	17.480	4.037	4.400	P<0.01
	60 deg	15.240	3.402		
3	45 deg	15.880	3.317	1.257	P>0.05 N/S
	60 deg	15.240	3.402		



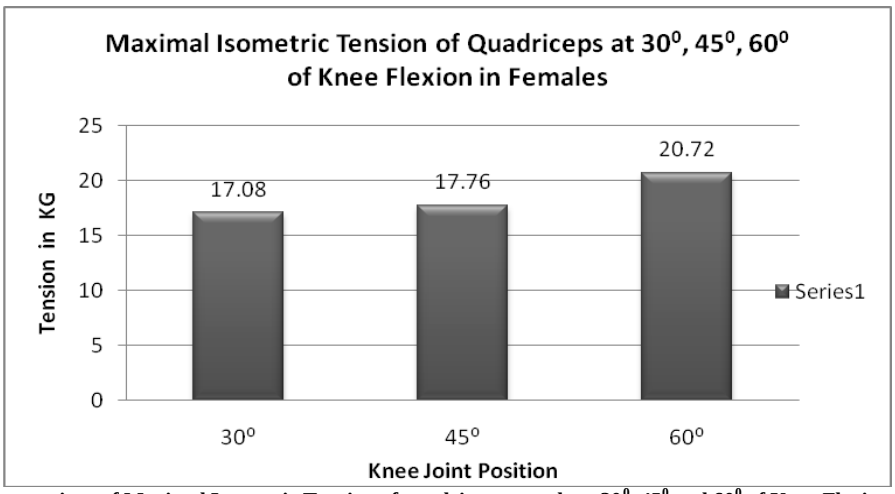
Graph 5: Comparison of Maximal Isometric Tension of Quadriceps muscle at 30^0, 45^0 and 60^0 of Knee Flexion in Males.



Graph 6: Comparison of Maximal Isometric Tension of hamstrings muscle at 30^0, 45^0 and 60^0 of Knee Flexion in Males.

Table 7: Comparison of Maximal Isometric Tension of quadriceps muscle at 30^0, 45^0 and 60^0 of knee flexion in females

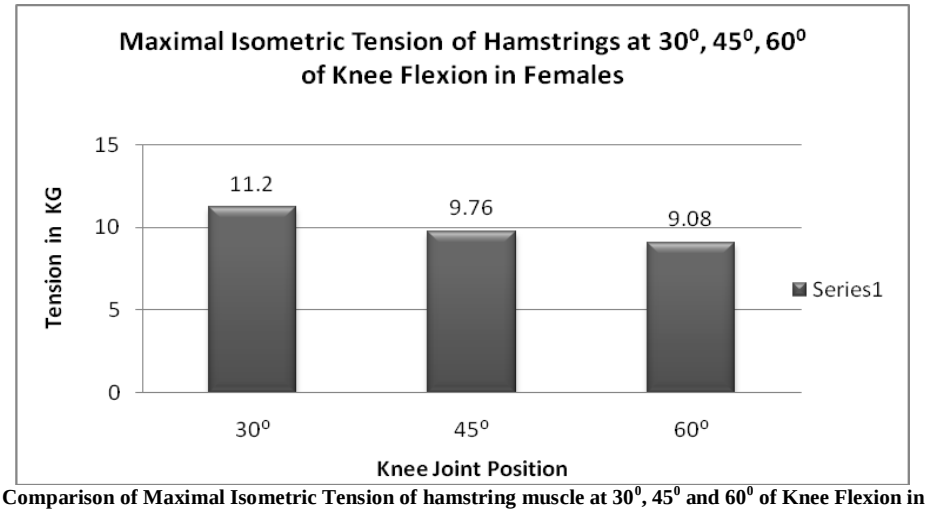
Si No	Groups	Mean	SD	Q Value	P Value
1	30 deg	17.080	3.029	1.349	P>0.05 N/S
	45 deg	17.760	3.537		
2	30 deg	17.080	3.029	7.219	P<0.001
	60 deg	20.720	4.056		
3	45 deg	17.760	3.537	5.870	P>0.001
	60 deg	20.720	4.056		



Graph 7: Comparison of Maximal Isometric Tension of quadriceps muscle at 30^0, 45^0 and 60^0 of Knee Flexion in Females.

Table 8: Comparison of Maximal Isometric Tension of hamstring muscle at 30^0, 45^0 and 60^0 of knee flexion in females

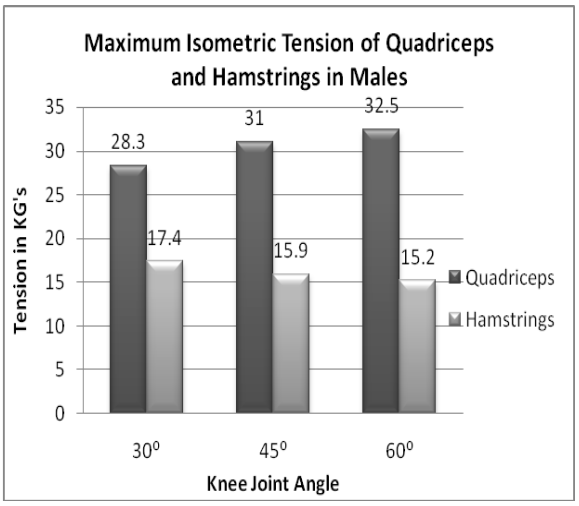
Si No	Groups	Mean	SD	Q Value	P Value
1	30 deg	11.200	2.740	3.922	P<0.05
	45 deg	9.760	2.759		
2	30 deg	11.200	2.740	5.774	P<0.001
	60 deg	9.080	2.257		
3	45 deg	9.760	2.759	1.852	P>0.05
	60 deg	9.080	2.257		



Graph 8: Comparison of Maximal Isometric Tension of hamstring muscle at 30^0, 45^0 and 60^0 of Knee Flexion in Females.

Table 9: Comparison of ratio maximal isometric tension of quadriceps and hamstring in males

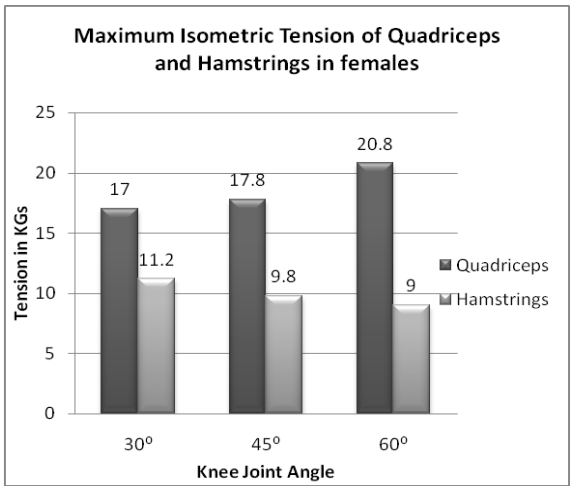
Knee joint angles	Quadriceps	Hamstring	Q:H ratio
30^0	28.3	17.4	1.6:1
45^0	31.0	15.9	1.9:1
60^0	32.5	15.2	2.1:1



Graph 9: Comparison of Maximal Isometric Tension of quadriceps and hamstring in males

Table 10: Comparison of ratio maximal isometric tension of quadriceps and hamstring in males

Knee joint angles	Quadriceps	Hamstring	Q:H ratio
30^0	17.0	11.2	1.5:1
45^0	17.8	9.8	1.8:1
60^0	20.8	9.0	2.3:1



Graph 10: Comparison of Maximal Isometric Tension of quadriceps and hamstring in females

RESULTS

Above table 1 to 4 shows that there was no statistically significant difference in maximal isometric tension of quadriceps and hamstring of dominant and non dominant lower extremity at 30^0 of knee flexion, 45^0 of knee flexion and 60^0 of knee flexion among males and females.

From the above table 5 to 8 the result showed that there was a statistically significant difference in the isometric strength of quadriceps and hamstring in the male subjects at 30^0 and 60^0 of knee flexion where as there was no statistically

significant difference in isometric quadriceps strength at 30^0 and 45^0 of knee flexion and 45^0 and 60^0 of knee flexion. Maximum isometric strength of quadriceps was found to be at 60^0 knee flexion.

Above table 9 and 10 shows that there was equal ratio were maintained between the hamstring and quadriceps isometric tension at all 3 different angles.

DISCUSSION

Table 1 to 4 shows that, this is in agreement with William Andrew et al (1996), in their study they identified dominant and non dominant side on basis of kicking a ball with lower extremity, and the strength of quadriceps and hamstring was assessed along with hip flexor abductor and ankle dorsiflexor they concluded that there was no significant difference between strength of the muscle in dominant and non dominant lower extremity. [(6)] According to Tae sek yoon et al the mean peak isometric values of both muscle group ratios showed no significant between dominant and non dominant leg. [(8)]

Since there was no difference in isometric strength at all 3 angles (30^0 of knee flexion, 45^0 of knee flexion and 60^0 of knee flexion) dominant and non dominant limbs the sample size could be increased including both dominant and non dominant limbs.

From the above table 5 to 8 this is in agreement with Marry moffroid et al, where there was peak torque of quadriceps occurred at 65 degree and the peak torque of knee flexor contraction was occurred at 35 degree assessed with the help of isokinetic dynamometer. [(9)]

Along with this, Patricia Murray et al, who found in his study that there was maximal isometric tension, was occurred in quadriceps muscle at 60^0 and maximal isometric tension of hamstring was occurred at 30^0 of knee flexion. [(1)]

This is mainly based on the isometric length tension relationship of the skeletal muscle.

Above table 9 and 10 shows This is in agreement with Adegoke et al, in his study he found that the mean isometric ratio of quadriceps and hamstring (Q: H) found to be 2:1 for young healthy adult. [(10)]

The above tables show that there is a statistically significant difference in the ratio of maximal isometric tension of quadriceps and hamstring at different angles of knee flexion, (30^0, 45^0 and 60^0) with hip position in neutral. So the alternate hypothesis is accepted.

CONCLUSION

50 healthy individuals including 25 males and 25 females were selected for this study. The maximal isometric tension produced in quadriceps and hamstring was assessed at 3 different angles namely 30^0 of knee flexion, 45^0 of knee flexion and 60^0 of knee flexion with the hip in neutral position.
The conclusion obtained from the statistically analysis is as following:
There was no significant difference between the dominant and non dominant, limb strength of quadriceps and hamstring in both males and females. The maximal isometric tension of quadriceps is highest at 60^0 knee flexion when compared to other 2 angles (30^0 & 45^0) knee flexion i.e. at outer range of quadriceps muscle.

The maximal isometric tension of hamstring is highest at 30^0 knee flexion when compared to other 2 angles (45^0 &60^0) knee flexion i.e. at outer range of quadriceps muscle.
The ratio of quadriceps/hamstring at 60^0 is 2.1:1 in males and 2.3:1in females.
The ratio of quadriceps/hamstring at 45^0 is 1.9:1 in male's and1.8:1 in females.
The ratio of quadriceps/hamstring at 30^0 is 1.6:1 in male's and1.5:1 in females.

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