ORIGINAL RESEARCH

IJPHY

# Effect of isometric quadriceps strengthening exercise at multiple angles in knee joint among normal adults.

**Jibi Paul**[1]

**Pradeep Balakrishnan**[2]

## ABSTRACT

***Introduction:*** Strengthening exercises have been routinely used in persons with orthopaedic problems and athletes to increase force production or minimize muscle imbalance and joint injuries.Many studies have reported that isometric contractions can rapidly increases strength in quadriceps muscle.

***Objective:*** Objective of the study was to find out the effect of isometric strengthening exercise on strength of quadriceps at 45 and 90 degree of knee joint and also to compare the effect of strengthening exercise on strength of quadriceps at multiple angles of knee joint among control and experimental group.

***Methodology:*** This was a ccomparative experimental study with forty female healthy subjects from physiotherapy department of KPJ Healthcare University College, Malaysia. Convenient sampling method used to select the samples. The subjects were selected by inclusion criteria and randomly divided equally in to two with 20 subjects in each group. Isometric strengthening exercise and squatting exercise were given as intervention program for eight weeks respectively for experimental and control group. Pre and post data of quadriceps muscle strength measured were collected separately at 45 and 90 degree of knee joint using goniometry during resisted extension of knee in multi gym.

***Result:*** In experimental group Pre –Post statistical analysis found significant effect in increase of quadriceps strength at 45 and 90 degree with P<0.0001.****In control group quadriceps pre-post statistical analysis found no significant effect in increase of quadriceps strength at 45 and 90 degree with P<0.083NS and P<0.055 NS respectively. Comparative study between experimental and control groups for quadriceps strength at 90 degree of knee joint found significant effect in increase of quadriceps strength with P< 0.001.*** Comparative study between experimental and control groups for quadriceps strength at 45 degree of knee joint found significant effect in increase of quadriceps strength with P<0.01*

***Conclusion:*** This study concluded that isometric strengthening exercise can improve quadriceps strength at 45 and 90 degree of knee joint. And also found that the strength at 90 degree has improved more compared to the strength at 45 degree.

***Key words:*** Muscle imbalance, quadriceps strengthening, multi gyms, squatting exercise, multi angles.

**CORRESPONDING AUTHOR**

[1]**Jibi Paul**, MPT, (PhD)
Physiotherapy programme, School of Health Sciences, KPJ Healthcare University College, Kota Seriemas 71800 Nilai, Negeri Sembilan, Malaysia.
Mail id: jibipaul74@gmail.com

[2]Pradeep Balakrishnan, MPT, Physiotherapy programme, School of Health Sciences, KPJ Healthcare University College, Nilai, Malaysia

## Introduction

Strengthening exercises have been routinely used in persons with orthopaedic problems and athletes to increase force production or minimize muscle imbalance and joint injuries. The most effective means of increasing strength by high resistance training remains unknown, despite the obvious importance of this knowledge for athletic training and rehabilitation.[1]High load strength training used to compare isometric, concentric and eccentric contractions. They found significantly greater increases in isometric strength after isometric training compared with concentric or eccentric contractions.[2,3, 4]

Studies that have employed isometric contractions have often reported large and rapid increases in strength by 40% in 8 weeks .Evidence of imbalanced muscle function, the contribution of quadriceps femoris muscle weakness has been well documented. The central hypothesis in this study is that quadriceps femoris muscle strength may vary in multiple angles.[5, 6, 7, 8]

## Research objective

Objective of the study was to find out the effect of isometric strengthening exercise on strength of quadriceps at 45 and 90 degree of knee joint and also to compare the effect of strengthening exercise on strength of quadriceps at multiple angles of knee joint among control and experimental group.

## Material and Methods

This was a ccomparative experimental study with forty female subjects from second and third year students (2013) of physiotherapy department of KPJ Healthcare University College, Malaysia. Convenient sampling method used to select the samples. The selected subjects were healthy females without any history of recent knee joint injury, quadriceps muscle pain. The subjects were randomly divided equally in to two with 20 subjects in each group with mean age group of 20.3 ± 0.79.The study setting did in physiotherapy skill lab of KPJUC, Malaysia. Isometric strengthening exercise and squatting exercise were given as intervention program for eight weeks respectively for experimental and control group. Pre and post data of quadriceps muscle strength measured were collected separately at 45 and 90 degree of knee joint using goniometry during resisted extension of knee in multi gym. Materials used for the study are Multi gym, goniometer and weights to perform the evaluation of quadriceps muscle strength.

## Procedure

Quadriceps exercise performed for both legs for five days in a week and continued for eight weeks. Experimental group performed Quadriceps strengthening by full extension of knee joint against 3 kg. Resistance with sand bag in high sitting position and hold for 10seconds followed by 5 seconds rest in flexed position. This exercise performed for 10 times per session.Control group performed Quadriceps strengthening by squat for 10 seconds followed by 5 seconds rest in standing position.This exercise performed for ten times per session.

Quadriceps strength of subjects evaluated using multi gym in sitting position. Trunk maintained in erected and hip stabilised at 90 degree flexed position, followed by active extension of knee joint against resistance. Quadriceps strength of weight lifted at 90 degree and 45 degree of knee joint recorded. Data collected before and after the prescribed exercise program by qualified

physiotherapist from KPJ Healthcare University College, Malaysia.

## Statistical Analysis

From the independent and dependant variables, summary measures evaluated and compared the differences. Dependent t' test used to compare the effect within the group. Independent t' used to compare the difference between the independent variables of two groups. P <0.05 has considered as significant difference in effects of the study.

## Result

In experimental group Pre –Post statistical analysis found significant effect in increase of quadriceps strength at 45 and 90 degree with P<0.0001****(Table1). In control group quadriceps Pre-Post statistical analysis found no significant effect in increase of quadriceps strength at 45 and 90 degree with P<0.083NS and P<0.055 NS respectively (Table2). Comparative study between experimental and control groups for quadriceps strength at 90 degree of knee joint found significant effect in increase of quadriceps strength with P< 0.001*** (Table3). Comparative study between experimental and control groups for quadriceps strength at 45 degree of knee joint found significant effect in increase of quadriceps strength with P<0.01* (Table:4)

**Table1.** Experimental group quadriceps strength at 45 and 90 degree of knee joint; significant effect found within the group.

| | Quadriceps strength at knee Joint Pre intervention (Mean ± SEM) | Quadriceps strength of at knee Joint Post intervention (Mean ± SEM) | T value | P-Value |
|---|---|---|---|---|
| 45 degree | 20.85 ± 0.79 | 22.60 ± 0.82 | 7.32,df=19 | P<0.0001**** |
| 90 degree | 26.05 ± 0.78 | 27.35 ± 0.85 | 7.26,df=19 | P<0.0001**** |

**Table2.** Control group quadriceps strength at 45 and 90 degree of knee joint; no significant effect found within the group.

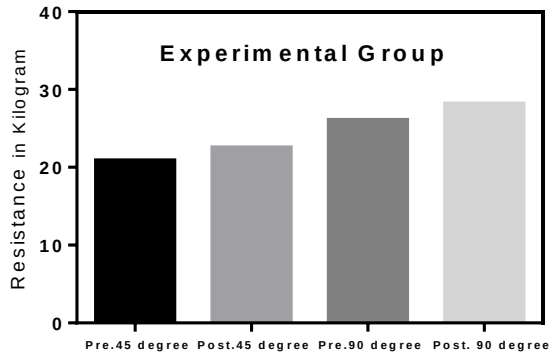
| | Quadriceps strength at knee Joint Pre intervention (Mean ± SEM) | Quadriceps strength of at knee Joint Post intervention (Mean ± SEM) | T value | P-Value |
|---|---|---|---|---|
| 45 degree | 18.85 ± 0.71 | 19.00 ± 0.68 | 1.83,df=19 | $0.083^{NS}$ |
| 90 degree | 24.15 ± 0.70 | 24.45 ± 0.67 | 2.04,df=19 | $0.055^{NS}$ |

**Table3.** Compared experimental and control group for quadriceps strength at 90 degree of knee joint; significant effect found between the groups.

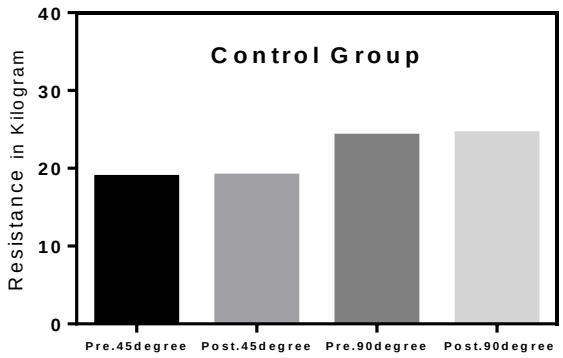
| Test | Quadriceps strength At 90 degree of knee Joint Experimental group (Mean ± SEM) | Quadriceps strength At 90 degree of knee Joint Control group (Mean ± SEM) | T value | P-Value |
|---|---|---|---|---|
| Pre intervention | 18.95 ± 0.73 | 20.85 ± 0.79 | 1.77,df=38 | 0.079$^{NS}$ |
| Post intervention | 19.00 ± 0.68 | 22.90 ± 0.84 | 3.61,df=38 | P<0.001*** |

**Table.4**Compared experimental and control group for quadriceps strength at 45 degree of knee joint; significant effect found between the groups.

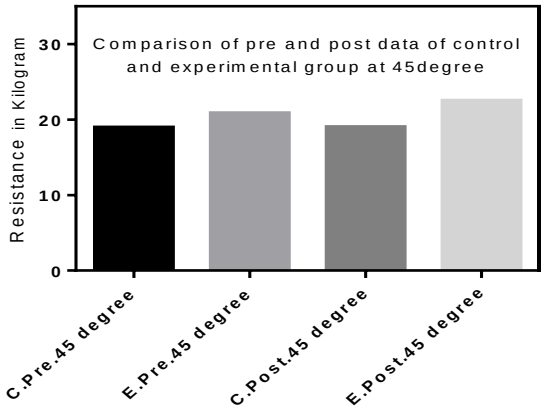
| Test | Quadriceps strength At 45 degree of knee Joint Experimental group (Mean ± SEM) | Quadriceps strength At 45 degree of knee Joint Control group (Mean ± SEM) | T value | P-Value |
|---|---|---|---|---|
| **Pre intervention** | 24.15 ± 0.70 | 26.05 ± 0.78 | 1.81,df=38 | 0.085NS |
| **Post intervention** | 24.45 ± 0.67 | 27.35 ± 0.85 | 2.68,df=38 | P<0.01* |



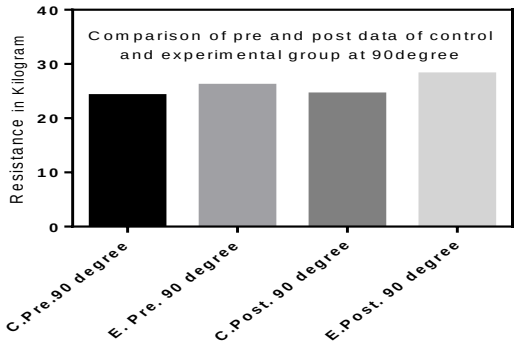

**Graph1.** Experimental group pre and post intervention quadriceps strength at 45 and 90 degree of knee joint; significant effect found within the group.




**Graph 2.** Control group pre and post intervention quadriceps strength at 45 and 90 degree of knee joint; no significant effect found within the group.




**Graph3.** Control and Experimental group pre and post intervention quadriceps strength at 45 degree of knee joint; significant effect found between the groups.




**Graph 4.** Control and Experimental group pre and post intervention quadriceps strength at 90 degree of knee joint; significant effect found between the groups.

## Discussion

Isometric quadriceps exercises performed at two different knee angles 15 and 60 degrees respectively to find out maximal torque in both positions before and after training in 10 healthy females. It was suggested that isometric exercise performed at different knee angles secure an optimal total strength increase.[9, 10, 11]

The outcome measures of isometric quadriceps torque, clinical status and pain were recorded before and after the exercise intervention. The exercises were carried out three times per week for a 6-week period with the subject seated on an exercise chair. Following training, quadriceps torque increased, clinical status improved, and pain with walking decreased. Subject to further investigation, isometric training of the quadriceps in mid-range could prove useful for improving the function of persons with painful or effused knees.[12]

Unilateral strength-training performed by seventeen volunteers of the quadriceps with high-resistance, low-repetition, dynamic exercise, thrice weekly for an average of 5 weeks. Bilateral measurements were made both before and after the training period, of isometric quadriceps strength, quadriceps cross-sectional area and thigh circumference. There were no significant changes in the untrained thighs. The trained quadriceps increased their isometric strength by more than they changed their cross-sectional area (mean increments = 15% and 6% respectively).[13, 14]

The maximal isometric knee extensor torque was recorded on an isokinetic dynamometer at knee angles of 90, 60, and 30 degrees for 6 weeks, 1 year, and 16 months. These data demonstrated a progressive torque increase at all angles over the 16-month period. Contrary to the specificity of training concept, Mid-range isometric strengthening exercises has proved useful in the rehabilitation of patients.[15,16, 17]

In this study we have analysed the bilateral tension strength of quadriceps at 45 and 90 degree. The subjects were able to lift more weight at 90 degree of knee joint level compared to the 45 degree level. This might be due to more angular pull of quadriceps muscle at 90 degree.

## Conclusion

This study concluded that isometric strengthening exercise can improve quadriceps strength at 45 and 90 degree of knee joint. And also found that the strength at 90 degree has improved more compared to the strength at 45 degree.

## Limitations

The intervention program was not performed under the supervision of researcher. Health and activities other than specified intervention program of subjects were not supervised during study period.

## Recommendation

This study can be recommended to do for both genders with more samples. This study can also recommend evaluating the quadriceps strength at right and left leg separately. Isokinetic dynamometer is recommended to use for exact quadriceps strength evaluation.

Acknowledgement

The authors would like to thank the management of KPJ Healthcare University College, also the chairman and members of research and development committee KPJUC, for their valuable suggestions and support to complete the study successfully.

## References

1. Folland JP, et.al. Strength training: isometric training at a range of joint angles versus dynamic training, J Sports Science. 2005; 23(8):817-24.
2. Jones, D. A., & Parker. Development of a portable strain gauge to measure human muscle isometric strength. Journal of Physiology.1989; 145, 11.
3. Jonathan p. Folland, et.al. Strength training isometric training at a range of joint angles versus dynamic training, Journal of Sports Sciences.2005; 23(8): 817 – 824.
4. Haakinen, K., Komi, P. V., &Tesch, P. A. Effect of combined concentric and eccentric strength training and detraining on force – time, muscle fibre, and metabolic characteristics of leg extensor muscles. Scandinavian Journal of Sports Science.1981; 3, 50 – 58.
5. Young, M et.al. The effects of two forms of isometric training on the mechanical properties of the triceps surae in man. Pflugers Archives. 1985; 405(4):384-8.
6. Jones, D. A., & Rutherford, (1987) Human muscle strength training: The effects of three different training regimes and the nature of the resultant changes. Journal of Physiology. 1987; 391:1-11.
7. Graves, J. E., et.al. Specificity of limited range of motion variable resistance training Medicine and Science in Sports and Exercise. 1989; 21(1):84-9.
8. Kitai, T. A., & Sale, D. G. Specificity of joint angle in isometric training. European Journal of Applied Physiology. 1989; 58(7): 744-748.
9. Thepaut-Mathieu, et.al. Myoelectrical and mechanical changes linked to length specificity during isometric training. Journal of Applied Physiology.1988; 64(4):1500 – 1555.
10. Kanehisa, H., & Miyashita, M. Effect of isometric and isokinetic muscle training on static strength and dynamic power. European Journal of Applied Physiology.1983; 50, 365 – 371.
11. Lindh, M. Increase of muscle strength from isometric quadriceps exercise at different knee angles. Scandinavian Journal of Rehabilitative Medicine.1979; 11(1):33–36.
12. Marks R. The effect of isometric quadriceps strength training in mid-range for osteoarthritis of the knee. Arthritis Care Res.1993; 6(1):52-6.

13. Weir, J. P., et.al. Effects of unilateral isometric strength training on joint angle specificity and cross-training. European Journal of Applied Physiology.1995; 70, 337 – 343.
14. Young, M. Stokes et.al. The effect of high-resistance training on the strength and cross-sectional area of the human quadriceps European Journal of Clinical Investigation, 1983;13(5): 411–417.
15. Marks R. The effects of 16 months of angle-specific isometric strengthening exercises in midrange on torque of the knee extensor muscles in osteoarthritis of the knee: a case study, J Orthop Sports Phys Ther.1994;20(2):103-9.
16. Parker, D. F, et.al. A cross-sectional survey of upper and lower limb strength in boys and girls during childhood and adolescence. Annuals of Human Biology.1990; 17(3)199 – 211.
17. Rutherford, O. M., Jones, D. A., and Newham, D. J. Clinical and experimental application of the twitch interpolation technique for the study of human muscle activation. Journal of Neurology, Neurosurgery and Psychiatry.1986; 49(11): 1288 –1291.

**How to cite this article:**

JibiPaul, Pradeep Balakrishnan. EFFECT OF ISOMETRIC QUADRICEPS STRENGTHENING EXERCISE AT MULTIPLE ANGLES IN KNEE JOINT AMONG NORMAL ADULTS. Int J Physiother. 2014; 1(1): 10-16.