ORIGINAL RESEARCH

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

Jibi Paul¹
Pradeep Balakrishnan²

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 increase 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 comparative 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 into 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<0.083 NS 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.

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**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. 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.\(^1\)\(^2\)\(^3\)\(^4\)

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 comparative 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 10 seconds 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.

<table>
<thead>
<tr>
<th>Quadriceps strength at knee Joint Pre intervention (Mean ± SEM)</th>
<th>Quadriceps strength of at knee Joint Post intervention (Mean ± SEM)</th>
<th>T value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 degree</td>
<td>20.85 ± 0.79</td>
<td>22.60 ± 0.82</td>
<td>7.32,df=19</td>
</tr>
<tr>
<td>90 degree</td>
<td>26.05 ± 0.78</td>
<td>27.35 ± 0.85</td>
<td>7.26,df=19</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Quadriceps strength at knee Joint Pre intervention (Mean ± SEM)</th>
<th>Quadriceps strength of at knee Joint Post intervention (Mean ± SEM)</th>
<th>T value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 degree</td>
<td>18.85 ± 0.71</td>
<td>19.00 ± 0.68</td>
<td>1.83,df=19</td>
</tr>
<tr>
<td>90 degree</td>
<td>24.15 ± 0.70</td>
<td>24.45 ± 0.67</td>
<td>2.04,df=19</td>
</tr>
</tbody>
</table>
**Table 3.** Compared experimental and control group for quadriceps strength at 90 degree of knee joint; significant effect found between the groups.

<table>
<thead>
<tr>
<th>Test</th>
<th>Quadriceps strength at 90 degree of knee joint (Mean ± SEM)</th>
<th>Quadriceps strength at 90 degree of knee Joint Control group (Mean ± SEM)</th>
<th>T value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre intervention</td>
<td>18.95 ± 0.73</td>
<td>20.85 ± 0.79</td>
<td>1.77, df=38</td>
<td>0.079 NS</td>
</tr>
<tr>
<td>Post intervention</td>
<td>19.00 ± 0.68</td>
<td>22.90 ± 0.84</td>
<td>3.61, df=38</td>
<td>P&lt;0.001***</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Test</th>
<th>Quadriceps strength at 45 degree of knee joint (Mean ± SEM)</th>
<th>Quadriceps strength at 45 degree of knee Joint Control group (Mean ± SEM)</th>
<th>T value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre intervention</td>
<td>24.15 ± 0.70</td>
<td>26.05 ± 0.78</td>
<td>1.81, df=38</td>
<td>0.085 NS</td>
</tr>
<tr>
<td>Post intervention</td>
<td>24.45 ± 0.67</td>
<td>27.35 ± 0.85</td>
<td>2.68, df=38</td>
<td>P&lt;0.01*</td>
</tr>
</tbody>
</table>

**Graph 1.** 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.
Graph 3. 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.\cite{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.\cite{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).\cite{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.\cite{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.

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References


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