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Comparison of the IEMG Activity Elicited During an Isometric Contraction Using Manual Resistance and Mechanical Resistance

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Abstract
Introduction: Quantification of muscle strength is an essential component of assessment and treatment in rehabilitation. Considering the measurement of the muscle strength, mostly two methods are used. They are qualitative and quantitative measures. Maximum voluntary isometric contraction (MVIC), measured using dynamometer and manual muscle testing (MMT) are the most common measurement techniques used in the clinical and research setting. Objectives: This study’s aim was to observe, if greater activity is produced using mechanical instruments for torque measurements (since the resistance is adjusted to subject’s maximum capacity) or if tests, position of MMT, and resistance offered by trained physiotherapist are effective. We compared the IEMG (Integrated electromyography) output between manual and mechanical testing during maximal voluntary isometric contraction. Subjects and Methods: Forty normal healthy subjects including 20 males and 20 females were selected for the study. The measuring system comprises an EMG (Noraxon USA, INC, Scottsdale, Arizona) and @HUR 5340 (Kokkola, Finland) leg extension/curl computer controlled machine for isometric evaluating peak torque. MVIC of the Vastus medialis oblique (VMO), Vastus lateralis (VL), Rectus femoris (RF), Semitendinosis (ST) and Biceps Femoris (BF) were measured from dominant leg using SEMG and then subjects were seated on HUR with hip flexed and chest, pelvis, thigh stabilized. The axis of rotation of HUR aligned with the joint axis and moment arm is fixed for every subject. Each subject performed maximal contraction of 10sec at 60°of test angle to get the peak torque and myoelectrical activity are also recorded while performing the same. Result: Paired t-test analysis were used to see the difference between MMT and HUR IEMG amplitude and the results show significance difference(p<.05) for each muscle when comparing between the EMG amplitude between MMT and HUR. Conclusion: HUR system has very good reliability in measuring muscle strength of

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the knee extensors and flexors as compared to the MMT, suggesting that it will be useful in clinical applications, especially for professional athletes or physically powerful populations.

**Key Words:** Muscle strength, IEMG, Isometric contraction

**Introduction**
Quantification of muscle strength is an essential component of assessment and treatment in rehabilitation. Muscle strength is the force exerted by a muscle or group of muscles to overcome a resistance in one maximal effort. For the measurement of the muscle strength, mostly two methods are used. They are qualitative and quantitative measures. Quantitative measures are those that are not dependent primarily on the judgment of the examiner. Such measures typically involve the use of instrumentation like dynamometers and are expressed in real numbers. On the other hand, measures like manual muscle testing, which involves the judgment of the examiner, is considered as qualitative. In assessing muscle strength, it is essential to describe the conditions surrounding the muscle contraction to interpret the data properly. In this study maximum voluntary isometric contraction (MVIC) is considered. Isometric muscle tests are the most common as they are the simplest to perform and reproduce. The test conditions are well defined, they are the most appropriate for comparing results within a population (1). MVIC, measured using dynamometer and manual muscle testing are the most common measurement techniques used in the clinical and research setting (3–5). Both have advantages and disadvantages. The simplest and most common method of assessing muscle strength is the manual muscle testing. Manual muscle testing is a procedure for evaluating strength and function of an individual muscle or a muscle group in which the patient voluntarily contracts the muscle against gravity load or manual resistance (1,2). MMT is an inexpensive method of testing strength that requires little equipment and personnel training but some studies have shown that MMT lacks the sensitivity to detect small but potentially important changes in muscle strength (5–8). Dynamometer provides interval data (typically in units of kilograms or Newtons of force) that are more objective than manual muscle testing and is a safe and simple method of assessing muscle strength. Dynamometric testing is not suitable for weak muscles when movement against resistance cannot be performed, as often occurs in the case of peripheral nerve lesions (9). Adding electromyography (EMG) during the muscle strength assessment method adds precision to the quantification method. It has long been recognized that mechanical tension and electromyographic (EMG) amplitude are directly related during isometric contraction (10–12). Lippold and Bigland demonstrated that during a voluntary contraction, the tension is proportional to the measurable electrical activity under isometric contractions (10,11,13,14). With an increase in the voluntary force more motor units are recruited and can be picked up by the surface electrodes. It is common practice to normalize the force (or torque) with respect to maximal isometric force that a subject can generate at the monitored joint. EMG normalization is frequently used to improve reliability by decreasing variation within and between individuals in EMG studies. The most common method of normalization is to compare the myoelectrical activity of a given contraction to the activity of Maximal voluntary isometric contraction (MVIC). In the very process of normalization in EMG study researcher uses the method of eliciting a MVIC. The position used to elicit this MVIC is a matter of controversy because at different knee joint angles the muscle is capable of producing different torque outputs. Researchers commonly use the position and angles described in the standard textbooks and procedures for eliciting manual muscle testing used in physical therapy to grade the strength of a muscle. Thus, this study was to observe, if greater activity was produced using mechanical instruments for torque measurements (since the resistance is adjusted to subject’s maximum capacity) or if tests, position of MMT, and resistance offered by trained physiotherapist are effective. The study is designed to compare the IEMG output between manual and mechanical testing during maximal voluntary isometric contraction.

**Methodology**

**Subjects**
Forty normal healthy subjects including 20 males (age 22.65±2.45 yr, height 170.6±5.8 cms, weight 67.45±10.36 kgs) and 20 females (age 21.3±1.89 yr, height 162.24±5.16 cms, weight 54.72±7.39 kgs) were selected for the study. All were right leg dominant and were not involved in any type of resistance training. They had no history of knee; hip or lower back pathology or surgery. Before testing, informed consent was obtained from each subject. The study was approved by ethical committee for research, GNDU Amritsar and a formal consent was obtained from all participants.

**Equipments**
The measuring system comprised of a 4-channel Myosystem
1200 electromyography (EMG) unit (Noraxon, USA Inc) and bipolar Ag-AgCl surface electrodes, measuring 1 cm in diameter with a center to-center distance of 2.5 cm to record the myoelectric activity. The EMG signals were amplified by the amplifier system. Driver line with the input impedance of 10 milliohm. Gain (fixed) = 1000 hz, kelihoodly A/D Converter ± 5 mv input range, Bandwidth- 10-500 hz with no notch filter.

HUR 5340 leg extension/curl computer controlled machine is an isoinertial dynamometer, which was used for evaluating isometric peak torque. This machine was the result of research project at the University of Technology in Helsinki, Finland.

Procedures

Skin impedance was reduced by shaving hair around the electrode site and wiping the skin with 70% of ethyl alcohol before applying the surface electrode. All the impedance level was below 5kohm before data collection started. Pairs of surface electrode with diameter of 1 cm and center to center spacing of 2.5 cm were applied to the dominant limb. The electrodes were covered with an electrically conducting gel and were positioned over the VMO, VL, RF, ST & BF of the lower limb under evaluation; and were attached using adhesive tape to avoid the movement artifact. For the VMO, the electrodes were placed on the VMO muscle belly, approximately 4 cm proximal to the superomedial border of the patella. For the VL, the electrodes were applied over the VL muscle belly, approximately 8 cm proximal to the lateral joint line of the knee. For the RF, the electrodes were placed at 50% of the distance from the anterior superior iliac spine to the superior pole of the patella (15). For Semitendinosis (ST), the electrodes were placed at 50% of the distance from the ischial tuberosity to the medial condyle of the femur. For Biceps femoris, the electrodes were placed at 50% of the distance from the ischial tuberosity to the lateral condyle of the femur. All electrodes were placed parallel to the corresponding muscle fiber. A ground electrode is placed on the proximal surface of tibia. After the preparation and positioning of electrode each subject warmed up on a stationary bicycle for five minutes. Soon afterwards, they performed sustained passive stretching of the hamstrings and quadriceps: two series of 30 seconds with an interval of 30 seconds. The purpose was to reduce any discomfort experienced by the subject during the MVIC and to reduce the intensity and duration of any post exercise muscle soreness. Data was recorded while each subject performed a MVIC (Maximum Voluntary Isometric Contraction) against fixed resistance for each muscle. MVIC of all muscles were recorded in manual muscle testing position in accordance with standard physical therapy guidelines (16). Subjects were in lying position on the treatment table/ stable base during all muscle testing and recordings. After recording the myoelectrical activity during MMT and then subjects were made sit on the chair of the HUR leg extension/curl with hip flexed at 110° and chest, pelvis, thigh stabilized. Before the final performance on the HUR, the activity was demonstrated to all the participants and they were made to practice the task and familiarize with the task for accurate readings. This was done before recordings the signals to ensure proper performance. The muscles were divided into two groups VMO, VL, & RF in first group and ST & BF in the second group.

The axis of rotation was aligned with the lateral condyle of the femur, and the moment arm is fixed for every subject. Test angles were presented in the midrange (600) of knee flexion and extension. Each subject performed only one maximal contraction for 10 seconds in extension direction and then in flexion, to get the peak torque for the quadriceps and hamstrings. The myoelectrical activity was also recorded while performing the same. All subjects were given consistent verbal encouragement during the maximal excursion.

Statistical analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS, Chicago, version 16.0). We utilized the peak EMG amplitude of HUR trials as the baseline, expressing the peak EMG amplitude of MMT trials as a ratio to that of HUR trials. Paired t-test was then used to test the changes in EMG peak amplitude between the MMT trials and HUR trials. The change in EMG amplitude for each muscles (VMO, VL, RF, ST, & BF) was calculated by subtracting the average amount of amplitude in the MMT trials from the average amount of amplitude in the HUR trials. The p value was set at the level of 0.05.

Before analyzing the EMG recordings the raw signals were full wave rectified and smoothed. This approach was based on the finding that the amplitude of rectified and smoothed EMG signals in a qualitatively related to the amount of force developed by the muscles. The signals during peak of contraction were analyzed. The full wave rectified and smoothed signals were analyzed with the root-mean-square (RMS) processing technique.

Results

To compare the output of two methods, 40 normal subjects
were taken and during the performance of manual and mechanical methods, EMG amplitude were taken and analyzed. Which was presented in the Table (1) shows the result of EMG amplitude ratio of the MMT to the HUR trials of MVIC. The results show that both males and females, elicited greater EMG amplitude while using HUR, rather than when using MMT.

To find the significant difference between the outcome of the two methods, we used the paired t-test and the result is presented in Table (2) which shows significance difference (p<.05) for each muscle when comparing between the EMG amplitude between MMT and HUR in both males and females.

**Discussion**

The purpose of this study is to compare the IEMG output between manual and mechanical testing during maximal voluntary isometric contraction. The findings of the present study showed a significant difference between manual EMG amplitude and mechanical EMG amplitude output of all the flexor and extensor muscles, revealing that mechanical EMG amplitude has an edge over the manual EMG amplitude (table 1). Table 2 represents the significant difference (p<0.05) between the two methods of assessing

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**Table 1.** Electromyographic (EMG) amplitude (µV) ratio between MMT and HUR maximal isometric testing of Quadriceps and Hamstrings in women and men. All Data are presented as mean ± standard deviation.

<table>
<thead>
<tr>
<th>Muscles Groups</th>
<th>Gender</th>
<th>EMG amplitude in MMT</th>
<th>EMG amplitude in HUR</th>
<th>MMT/HUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vastus Medialis Oblige</td>
<td>Women</td>
<td>544±184</td>
<td>722±166</td>
<td>0.782±0.306</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>722±331</td>
<td>1089±277</td>
<td>0.683±0.306</td>
</tr>
<tr>
<td>Vastus Lateralis</td>
<td>Women</td>
<td>816±393</td>
<td>1298±695</td>
<td>0.721±0.300</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>924±424</td>
<td>1245±678</td>
<td>0.782±0.212</td>
</tr>
<tr>
<td>Rectus Femoris</td>
<td>Women</td>
<td>625±234</td>
<td>830±396</td>
<td>0.806±0.231</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>873±390</td>
<td>1106±606</td>
<td>0.845±0.295</td>
</tr>
<tr>
<td>Semitendinos</td>
<td>Women</td>
<td>396±211</td>
<td>581±161</td>
<td>0.735±0.456</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>875±393</td>
<td>1245±248</td>
<td>0.717±0.353</td>
</tr>
<tr>
<td>Biceps Femoris</td>
<td>Women</td>
<td>412±166</td>
<td>541±115</td>
<td>0.777±0.303</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>574±188</td>
<td>801±200</td>
<td>0.726±0.228</td>
</tr>
</tbody>
</table>

**Table 2.** Paired t test analysis of differences in electromyographic parameters between maximal manual testing and HUR maximal isometric testing in women and men.

<table>
<thead>
<tr>
<th>Muscle Groups</th>
<th>Gender</th>
<th>T</th>
<th>Df</th>
<th>Significance level</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff_amp Vastus Medialis Oblige</td>
<td>Women</td>
<td>-3.506</td>
<td>19</td>
<td>0.002</td>
<td>-1.784</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>-4.61</td>
<td>19</td>
<td>0.000</td>
<td>-3.672</td>
</tr>
<tr>
<td>Diff_amp Vastus Lateralis</td>
<td>Women</td>
<td>-4.843</td>
<td>19</td>
<td>0.000</td>
<td>-4.820</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>-3.33</td>
<td>19</td>
<td>0.004</td>
<td>-3.211</td>
</tr>
<tr>
<td>Diff_amp Rectus Femoris</td>
<td>Women</td>
<td>-3.151</td>
<td>19</td>
<td>0.005</td>
<td>-2.043</td>
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<tr>
<td></td>
<td>Men</td>
<td>-2.67</td>
<td>19</td>
<td>0.015</td>
<td>-2.876</td>
</tr>
<tr>
<td>Diff_amp Semitendinos</td>
<td>Women</td>
<td>-3.289</td>
<td>19</td>
<td>0.004</td>
<td>-1.840</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>-4.13</td>
<td>19</td>
<td>0.001</td>
<td>-3.699</td>
</tr>
<tr>
<td>Diff_amp Biceps Femoris</td>
<td>Women</td>
<td>-3.440</td>
<td>19</td>
<td>0.003</td>
<td>-1.279</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>-5.67</td>
<td>19</td>
<td>0.000</td>
<td>-2.268</td>
</tr>
</tbody>
</table>
In conclusion, the examiner’s muscle strength affects the inter-examiner reliability of muscle strength measurements using the MMT. Insufficient examiner muscle strength leads to poor inter-examiner reliability with the MMT. So using HUR, which provides constant output forces, solves this problem by increasing reliability of outcomes. Our study shows that HUR system has very good reliability in measuring muscle strength of the knee extensors and flexors as compared to the MMT, suggesting that it will be useful in clinical applications, especially for professional athletes or physically powerful populations. The limitation of our study is that it included only collegiate population and it allowed only one maximal contraction for both manual and mechanical methods.

References

9. Beasley WC: Influence of method on estimates