Reliability of hand-held dynamometer for strength testing of knee musculature in healthy Indian pediatric population: a cross-sectional study.

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ABSTRACT

Objective: This study was designed to determine intra-rater and inter-rater reliability of hand held dynamometer for testing knee flexors and extensors isometric muscle strength.

Study Design: Cross sectional study

Subjects: 29 young healthy children, 15 boys and 14 girls between the age group of 10 -15 years with mean age 12.58 ± 1.63 (Mean ± SD) were included in the study.

Methodology: Subjects were tested with a Baseline portable hand held dynamometer on three separate occasions by two separate examiners to determine maximal isometric strength values for knee flexors, and knee extensors.

Results: The mean scores for knee flexion and extension exhibited excellent inter-rater reliability with ICC ranging from 0.93 to 0.96 and moderate to good intra-rater reliability with ICC ranging from 0.65 to 0.86 at 95% CI.

Conclusion: The hand held dynamometer is a reliable tool to use in determining lower limb muscle force production. And it can be reliably used in assessment of muscle strength in healthy pediatric population age 10-15 years.

Implications: Since the hand held dynamometer has been found to be reliable in healthy pediatric population, further studies are recommended for its reliability in children with various dysfunctions.

Key words: hand-held dynamometer, isometric muscle strength, reliability, pediatric population.

INTRODUCTION

Muscle Strength is the ability of a muscle to produce force. Alteration in muscle strength can affect functional performance, work productivity and the efficiency of the movement. Strength testing is an important component in examination and diagnosis. It is important to have precise quantitative measures of strength, particularly for children in determining clinical progression of neuro-muscular weakness as well as assessing the response of the intervention.

There are many methods of muscle testing like manual muscle testing, isokinetic dynamometry and hand held dynamometry etc. among these Manual muscle testing is frequently used for assessing the strength in children, assigning MMT grades largely relies upon the examiners judgment of the amount of force generated by the subject & therefore is subjective and prone to examiner bias. In addition, small yet clinically significant changes in strength may not be detected by MMT. Individual examiners vary

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significantly in the amount of force applied to the limbs, particularly when assigning MMT grades 0-3, however MMT does not adequately quantify muscle strength, particularly for grades 3+ to 5. Although it is widely used to quantify muscle strength, its reliability and sensitivity has always been questioned.

The accurate method of strength evaluation is through isokinetic dynamometry. It uses computer controlled equipments to measure the muscle force generated throughout a controlled movement. Isometric load cell system also provides more limited information since the strength is measured only at a specific point in the range of motion. Isokinetic method is commonly used in the research settings and is proven to be reliable and valid. Such equipment is usually impractical in the clinical settings due to experience, space requirement, specialized technical training and limited number of muscle group which can be reliably tested.

The remaining alternative objective method for measuring muscle strength is through hand held dynamometer (HHD). It consists of a simple hand held device equipped with a small internal load cell capable of measuring the muscular force. The hand held dynamometer offers significant potential advantages when compared to other laboratory methods of strength assessment like lower cost, portability, greater ease of admonition, relatively inexpensive and better adaptability to clinical settings.

The first critical step in evaluating a measurement method is to determine its reliability. Reliability refers to the ability of the instrument to repeatedly measure the same number. A reliable instrument is consistent. There are two kinds of reliability. One is intra-rater reliability and the other is inter-rater reliability. Intra-rater reliability refers to whether the device is reliable when testing is administered repeatedly by the same person. Inter-rater reliability refers to whether the device is reliable when testing is administered by different persons.

Strength assessment using a HHD might be a valuable measurement instrument for monitoring changes over time in clinical practice. The reliability of the HHD is considered to be good for various populations of patients by using several varieties of dynamometers. But Studies are mainly warranted for child population.

Although all the muscle groups are involved in reliability testing common conclusive evidence is there for only few muscles. Most of the studies are mainly done on knee joint muscles because of their importance in functional activities. Intermediate joint muscles are lack of obvious trick movements due to limited plane of movements so they are useful to determine the reliability of equipment accurately.

Therefore our study aimed to determine the inter-rater and intra-rater reliability of hand held dynamometer in knee flexors and extensors of normal children age 10-15 years by using Base line digital push pull hand held dynamometer.

**Methodology**

**Subjects**
This observational study involve 29 children of age between 10-15 years with mean age12.58 ± 1.63 (Mean ± SD). Among these 15 were boys and 14 were girls. Children were recruited from the random sampling method from a randomly selected school i.e. Urwa government higher primary School, near Urwa market, Mangalore.

**Inclusion criteria**
1. Boys and girls within the age of 10 to15 years.
2. Normal, full range of motion without pain and strength of both lower extremities.

**Exclusion criteria**
1. Any health related problems (including simple conditions like cold or fever etc. which can affect the child performance) that can affect strength.
2. Any condition that would have led to inability to follow the instructions or carry out the test procedure or totally uncooperative subject.
3. Severe uncorrected vision or hearing.
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4. If height or weight fell below the 10th or above the 90th percentile for gender and age.

Materials

Baseline push pull digital hand held dynamometer with 250lb/120Kg capacity, which can measure strength in kilograms (kg) or in pounds (lb). This dynamometer has two ends one side is push side and another side is pull side. It has only five buttons that is on/off, zero, max, max clear, lb/kg. On/off button for switching on and off the equipment, zero button to ensure that you are starting from zero measurement, max button to memorize the last maximum reading, max clear button to clear the last maximum reading and lb/kg button is to shift either to pounds or kilograms. Machine is battery operated and requires two AAA batteries to work. Two inch wide digital screen shows the strength measurement, battery life and lb or kg according to choice (figure 1). Inch tape, weighing scale, rolled towel padding and a couch are the other required materials.

Two male Physical Therapists with Masters in Physical Therapy qualification were participated in this study both have experience in using hand held dynamometer and both therapists were trained to use hand held dynamometer. Study was conducted in school. Duration of study was 6 months.

Procedure

Purpose of the study was explained to school authorities and parents and consent form was obtained from parents/guardian. Children were undergone complete examination to rule out all inclusion and exclusion criteria. Children were explained regarding the procedure with demonstration. The highly reliable make test compared to break test while measuring with HHD which is operationally defined as the maximum effort exerted against a stationary hand held dynamometer was used to quantify the subjects knee extensor and flexor isometric muscle force production. Measurement obtained was in pounds. Three measurements were taken for each muscle group.
Knee extensors (Figure- 2)

PATIENT POSITION:
The patient is in a sitting position. A small towel roll placed distally to support the femur in 90 degree of hip flexion. The knee is maintained in 70 degree of knee flexion.

PLACEMENT OF THE DYNAMOMETER:
On the front of the leg slightly above the ankle. A rolled towel padding was used over the shin to prevent the discomfort of the child.

TEST PROCEDURE:
The Patient is asked to make the knee straight pushing the dynamometer with the leg. The therapist is in front of the patient and holding the dynamometer sturdily in the place. The patient is given instructions such as “please kick as hard as u can”. The contraction is held for 5 seconds. Three measurements were taken per rater for each muscle group with a 30 second rest between each measure. For each rater the knee joint angle was ensured to be at 70 degrees by measuring with goniometer.

Knee flexors (Figure-3)

PATIENT POSITION:
The patient is prone on the bed with the test side leg flexed to 90 degrees and the non test leg straight.

PLACEMENT OF DYNAMOMETER:
On the back of the leg slightly above the ankle.

TEST PROCEDURE:
The patient is asked to bend the knee from the 90 degree flexed position. The therapist is in side of the patient and holding the dynamometer sturdily in the place. The patient is continuously told to pull the heel towards the buttocks. The contraction is held for 5 seconds. Three measurements were taken per rater for each muscle group with a 30 second rest between each measure. For each rater the knee joint angle was ensured to be at 90 degrees by measuring with goniometer.

Data analysis
Data collected was analyzed by using statistical package SPSS version 11. Data obtained from children was in pounds, both raters' data was computed and analyzed by reliability statistics. Alpha values were obtained by setting intraclass correlation coefficient (ICC) value at 95% of confidence interval with absolute agreement. To find out the agreement and mean values of data paired t test was done. P value set to be significant if it is <0.05. Alpha values between 0.6 to 0.8 shows moderate agreement and >0.8 shows strong agreement.

Results
DEMOGRAPHIC DATA
Out of 29 young healthy children, 15 were boys and 14 were girls between the age group of 10 -15 years with mean age12.58 ± 1.63 (Mean ± SD).
**PRINCIPAL OUTCOMES**

The inter-rater reliability has shown strong agreement. Alpha values ranging from 0.93 to 0.96 which were shown in table-1. The intra-rater reliability has shown moderate to strong agreement. Alpha values were ranging from 0.65 to 0.86 which were shown in table-2.

**SECONDARY OUTCOMES**

The mean values of knee flexors and extensors of right and left sides of both raters for inter-rater and intra-rater reliability were identical, this was observed from paired t-test statistics which were shown in table-1 and 3. Knee extensors and flexors mean values for both genders were graphically represented in figure-4 and 5.

**DISCUSSION**

Results of this study provided the intra-rater and inter-rater reliability estimates for portable baseline hand-held digital push pull dynamometer in children between 10 to 15 years. Our strength scores were generally found to exhibit an excellent reliability (table-1).
A review of the literature determined that measurement procedures, instrumentation, data analysis and sample characteristics vary extensively.\textsuperscript{10, 11} Even though the study process is different the values were comparable with each other for example Ford smiths study on adults revealed good reliability ICC scores 0.85 for knee muscles varying from 0.66 to 0.95 at 90\% of confidence interval.\textsuperscript{10} Our study shows similar kind of results even in children. Intra rater reliability ICC scores 0.82 for knee muscles varying from 0.65 to 0.86 at 95\% confidence interval (table-2).

Similarly Knols study on adult cancer patients revealed good inter rater reliability ICC score 0.96 for knee muscles varying from 0.92 to 0.98 at 95 \% confidence interval.\textsuperscript{12} In our study also we got similar findings for inter rater reliability ICC scores 0.95 varying from 0.93 to 0.96 at 95\% confidence interval (table-2). The standard protocol of studying few knee muscles which are in the intermediate joint with less degrees of mobility had increased the strength of this research.

In general most subjects in our study showed higher strength scores during the retest session than during the first testing session, this could be because of familiarity with the test and the testing procedures during the second session. Boys showed the capacity to produce more force than girls in all the muscle groups tested (figure one and two), which is consistent with the finding of other researchers\textsuperscript{13, 14} where males have greater capacity to produce muscle force than females and as the age progresses their strength values were increasing.

Even though knee flexors can be checked in sitting position we had adopted prone position to reduce the trick movements of trunk, so that we will get accurate values of knee flexors with out super imposition of trunk muscles. But knee extensors can not be satisfactorily checked in supine position because of lack of stability for thigh region so it has to be checked in sitting only.

In some standard protocols of isometric muscle testing a fabricated frame was used to stabilize the dynamometer\textsuperscript{10}. In our study it was not used because the amount of force generated by children may not be too high like adults whom the therapist can resist isometrically and secondly the fabricated frame

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Figure 5 Comparison of mean values of knee flexor muscle strength for both raters in boys and girls

Gender

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Table-1: Knee flexors and extensors mean strength values of both raters and inter-rater reliability (ICC values)

<table>
<thead>
<tr>
<th>Muscle group</th>
<th>Side of testing</th>
<th>Rater(s)</th>
<th>Mean ± SD</th>
<th>Inter-rater reliability ICC (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee extensor muscle strength</td>
<td>Right side</td>
<td>Rater 1</td>
<td>22.93±2.27</td>
<td>.96 (.93-.98)</td>
<td>.828 (NS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>22.90±2.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left side</td>
<td>Rater 1</td>
<td>22.85±1.93</td>
<td>.95 (.89-.97)</td>
<td>.055 (NS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>22.55±1.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee flexor muscle strength</td>
<td>Right side</td>
<td>Rater 1</td>
<td>21.77±1.88</td>
<td>.93 (.86-.97)</td>
<td>.271 (NS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>21.58±2.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left side</td>
<td>Rater 1</td>
<td>21.40±2.21</td>
<td>.93 (.85-.96)</td>
<td>.687 (NS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>21.47±1.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ICC- Intra-class correlation co-efficient; CI- confidence interval; NS- not significant at p < .05 level; SD- standard deviation

Table-2: Knee flexors and extensors mean strength values of both trials of individual raters and intra-rater reliability (ICC values)

<table>
<thead>
<tr>
<th>Muscle group</th>
<th>Side of testing</th>
<th>Rater(s)</th>
<th>Trial(s)</th>
<th>Mean ± SD</th>
<th>Inter-rater reliability ICC (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee extensor muscle strength</td>
<td>Right side</td>
<td>Rater 1</td>
<td>Trial-1</td>
<td>22.72±2.13</td>
<td>.86 (.73-.93)</td>
<td>.255</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>Trial-2</td>
<td>23±2.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left side</td>
<td>Rater 1</td>
<td>Trial-1</td>
<td>22.93±2.47</td>
<td>.81 (.64-.90)</td>
<td>.897</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>Trial-2</td>
<td>22.89±2.14</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Right side</td>
<td>Rater 1</td>
<td>Trial-1</td>
<td>23.1±2.05</td>
<td>.65 (.36-.82)</td>
<td>.924</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>Trial-2</td>
<td>23.13±2.23</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Left side</td>
<td>Rater 1</td>
<td>Trial-1</td>
<td>22.37±2.41</td>
<td>.69 (.44-.84)</td>
<td>.634</td>
</tr>
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<td></td>
<td></td>
<td>Rater 2</td>
<td>Trial-2</td>
<td>22.55±2.48</td>
<td></td>
<td></td>
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<tr>
<td>Knee flexor muscle strength</td>
<td>Right side</td>
<td>Rater 1</td>
<td>Trial-1</td>
<td>21.37±1.95</td>
<td>.71 (.48-.85)</td>
<td>.074</td>
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<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>Trial-2</td>
<td>21.89±2.16</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Left side</td>
<td>Rater 1</td>
<td>Trial-1</td>
<td>21.62±2.49</td>
<td>.76 (.55-.88)</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>Trial-2</td>
<td>21.62±2.35</td>
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<td></td>
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<tr>
<td></td>
<td>Right side</td>
<td>Rater 1</td>
<td>Trial-1</td>
<td>21.31±2.71</td>
<td>.81 (.65-.91)</td>
<td>.905</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>Trial-2</td>
<td>21.34±2.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left side</td>
<td>Rater 1</td>
<td>Trial-1</td>
<td>21.51±2.44</td>
<td>.68 (.42-.83)</td>
<td>.850</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rater 2</td>
<td>Trial-2</td>
<td>21.58±2.39</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ICC- Intra-class correlation co-efficient; CI- confidence interval; NS- not significant at p < .05 level; SD- standard deviation
is not practical in all the clinical settings.

Not using the fabricated frame might have caused some error in the measurement but which may be similar for both the therapists. But for the clarification of findings in future the reliability should be checked with and without fabricated stabilization frame. Results of this kind of future studies can increase our clinical confidence in using the dynamometers.

Further research is warranted for establishing reliability in each gender separately and in all the age groups of children. Reliability of different muscle groups also should be done so that the therapist confidence increases in choosing the dynamometer as a standard clinical outcome measure.

CONCLUSION

Strength testing with a hand held dynamometer has moderate to good intra-rater and very good inter-rater reliability to measure group mean changes in knee muscle strength of children age 10 to 15 years. This hand held dynamometer is comparatively inexpensive, portable and accessible to a large number of subjects.

ACKNOWLEDGMENTS

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CONFLICTS OF INTEREST

None identified and/or declared

REFERENCES


