A New Tool to Measure Isometric Knee Flexor & Extensor Strength in Older Adults

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Background
To determine whether the HUR Performance Recorder (PR1) is a tool that could be confidently used as an outcome measure in rehabilitation and research.

To test the HUR PR1’s:
- intra-rater reliability
- inter-rater reliability
- convergent validity against the Biodex dynamometer.
What is the HUR PR1?

HUR PR1

HUR 5530
Why Measure Strength?

- Outcome Measure
  - Rehabilitation
  - Research

- Strength may determine:
  - functional mobility
  - ability to perform ADL’s
Why Isometric Strength?

- Simple to perform, compare, & reproduce
- Strong predictor of functional capacity
Why Older Adults?

- Canada’s aging population
- OA prevalence
  - 3rd most common chronic condition in Canada
- Activity promotion
Why Knee Flexors/Extensors?

- Knee OA
- Predictive of function
- Limitations of other methods
Why Biodex?

- The gold standard for validity and reliability in testing muscle strength

WHY NOT JUST USE BIODEX?

- Access
- Cost
HUR PR1

- Affordable
- Accessible
- Has not yet been tested
- Potential uses in future rehab and research projects
Methods
Subjects

- Healthy independently living older adults from lower mainland
  - Inclusion criteria
    - 55–75 years of age
  - Exclusion criteria
    - Cardiovascular disease, neuromuscular or musculoskeletal disorders
      - Par–Q
  - No selection criteria for current physical activity level
Subjects

- Recruitment – Convenience sample
  - Vancouver Community Centres
  - UBC Changing Aging Program
  - Word of mouth
Sample Size

- Common statistical practice:
  - Alpha level 0.05
  - Power $\geq 0.80$

- Assumptions
  - There will not be a great deviation between the HUR PR1 tests
  - There will not be a great deviation between the HUR PR1 and Biodex
## Sample Size

Sample Sizes needed for correlation coefficient (r)

<table>
<thead>
<tr>
<th>Power</th>
<th>.10</th>
<th>.20</th>
<th>.30</th>
<th>.40</th>
<th>.50</th>
<th>.60</th>
<th>.70</th>
<th>.80</th>
<th>.90</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha = .05 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.70</td>
<td>470</td>
<td>117</td>
<td>52</td>
<td>28</td>
<td>18</td>
<td>12</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>.80</td>
<td>617</td>
<td>153</td>
<td>68</td>
<td>37</td>
<td>22</td>
<td>15</td>
<td>10</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>.90</td>
<td>854</td>
<td>211</td>
<td>92</td>
<td>50</td>
<td>31</td>
<td>20</td>
<td>13</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

Adapted from Table C.6 in Portney, L. and M. Watkins, *Foundations of Clinical Research Applications to Practice*
**Instrumentation**

- **HUR 5530 and PR1**
  - Calibration as per manufacturer
  - Fixed joint angle
    - Lateral epicondyle in-line with lever arm rotation axis
    - Assess joint angle with goniometer
  - Ankle pad proximal to malleoli for comfort

- **Biodex**
  - Calibration as per manufacturer
  - Angles to match HUR

- **Measure = Peak Torque (Nm)**

- **Measure = Force (kg)**
Study Design

- Test–Retest Reliability – HUR PR1
  - Intra–rater reliability
  - Inter–rater reliability

- Convergent validity – Biodex vs. HUR
Design

Informed Consent → Familiarization → 2–5 Days Rest

Test Day 1
- HUR Test 1 (T1)
- Rest
- Biodex Test (T3)

2–5 Days Rest

Test Day 2
- HUR Test 2 (T1)
- Rest
- HUR Test 3 (T1)
- Rest
- HUR Test 4 (T2)
Randomization

- Randomized and counter-balanced (Using concealed envelope)
  - Test Day 1 – Randomized order of tests
  - Test Day 2 – Randomized order of examiners
  - Flexion first vs. Extension first
    - Alternated for each testing session
Randomization Options

Day 1
- HUR1
- BD

Day 1
- BD
- HUR1

Day 2
- HUR2
- HUR1
- HUR1

Day 2
- HUR1
- HUR1
- HUR2
5 minute warm-up
  • Cycle ergometer (50W)

3 minute rest period

3 submaximal trials
  • 50–60% perceived exertion

3 maximal trials

3 submaximal trials
  • Opposite movement

3 maximal trials
  • Opposite movement

Dominant leg used
Data Analysis

- Data from HUR PR1 converted from kilograms to peak torque (Nm)
  - Mean of 3 trials
  - Group mean

- Max and mean torque compared using SPSS statistical software
Data Analysis

- Reliability
  - ICC
  - Pearson $r$

- Validity
  - Pearson $r$
  - Bland–Altman Plot
# Participant Characteristics

Table 1. Participant characteristics

<table>
<thead>
<tr>
<th></th>
<th>All Participants n = 12 Mean (SD)</th>
<th>Male n = 6 Mean (SD)</th>
<th>Female n = 6 Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>63.5 ± 5.6</td>
<td>65.2 ± 6.3</td>
<td>61.8 ± 4.8</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.73 ± 0.09</td>
<td>1.80 ± 0.04</td>
<td>1.66 ± 0.06</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>84.5 ± 22.5</td>
<td>100.7 ± 21.0</td>
<td>68.4 ± 6.7</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>28.0 ± 5.5</td>
<td>31.2 ± 6.2</td>
<td>24.9 ± 2.2</td>
</tr>
<tr>
<td>Dominance: n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>10 (83%)</td>
<td>5 (83%)</td>
<td>5 (83%)</td>
</tr>
<tr>
<td>Left</td>
<td>2 (17%)</td>
<td>1 (17%)</td>
<td>1 (17%)</td>
</tr>
</tbody>
</table>
Calibration

- HUR PC software issues
- Defaulted to zeroing HUR PR1
- Retested select subjects with calibration post-data collection
  - Regression equation
    - n=3
# Intra-rater Reliability

## Average Torque

<table>
<thead>
<tr>
<th></th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>0.897</td>
</tr>
<tr>
<td>Extension</td>
<td>0.893</td>
</tr>
</tbody>
</table>

## Maximum Torque

<table>
<thead>
<tr>
<th></th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>0.753</td>
</tr>
<tr>
<td>Extension</td>
<td>0.943</td>
</tr>
</tbody>
</table>

\( p < 0.005 \)
Intra–rater Reliability

Intra–class Correlation Coefficient (ICC)
(CI = Confidence Interval)

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Intra-rater Average ( 95% CI)</th>
<th>Intra-rater Maximum ( 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>.893 (.684 - .968)</td>
<td>.727 (.316 - .912)</td>
</tr>
<tr>
<td>Extension</td>
<td>.886 (.650 - .966)</td>
<td>.929 (.773 - .939)</td>
</tr>
</tbody>
</table>
### Inter-rater Reliability

<table>
<thead>
<tr>
<th>Average Torque</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>.881</td>
</tr>
<tr>
<td>Extension</td>
<td>.886</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum Torque</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>.749</td>
</tr>
<tr>
<td>Extension</td>
<td>.954</td>
</tr>
</tbody>
</table>

$p < 0.005$
### Intra-class Correlation Coefficient (ICC)

(CI = Confidence Interval)

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Inter-rater Average (95% CI)</th>
<th>Inter-rater Maximum (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>.889 (.660 - .967)</td>
<td>.746 (.347 - .919)</td>
</tr>
<tr>
<td>Extension</td>
<td>.886 (.662 - .966)</td>
<td>.934 (.739 - .982)</td>
</tr>
</tbody>
</table>
## Validity

<table>
<thead>
<tr>
<th>Biodex vs. HUR PR1</th>
<th>$r$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>.847</td>
<td>.001</td>
</tr>
<tr>
<td>Extension</td>
<td>.873</td>
<td>.000</td>
</tr>
</tbody>
</table>
Validity: Flexion Line of Identity
Validity: Ext. Line of Identity

[Graph showing a line of identity with data points and an indicated relationship between Extension Torque: HUR PRI (Nm) and Extension Torque: Biodex (Nm).]
Bland–Altman Plot: Flexion

The plot shows the difference in flexion force between Biodex and HUR 5530 & PR1 against the average flexion force. The range of differences is from -60 Nm to 60 Nm, with a center line at 0 Nm. The mean difference is 46.26 Nm, and the 95% limits of agreement are approximately -21.36 to 103.84 Nm.
Bland–Altman Plot: Extension

![Bland–Altman Plot](image_url)
Discussion
Reliability

- Good intra- and inter-rater reliability
  - Repeatability of the force transducer
  - Standardized protocol

- Extension vs. Flexion
  - Trend toward greater reliability with extension
  - Error from counter-moment force
    - Counter-moment greater from extensors
  - HUR 5530 set-up
    - Immovable pad vs. straps
Validity

- Good criterion-referenced validity to Biodex
- Unbiased error
- Wide confidence limits
  - Calibration issues?
    - Regression equation
Problems and Challenges

- HUR PR1 Unit
  - Major issues with software
  - Hardware malfunctions
  - Calibration issues
  - Limited access to IT support

- Recruiting
  - Slow to recruit adequate sample size

- Time
  - Constraints related to course schedule
Limitations

- Data extrapolated using a regression formula based on a sample within the sample

- Predetermined joint angle limits clinical applications

- Generalizability
  - Healthy older adults
Future Research

- Calibrated trials
  - Using HUR PR1 software
- Use with different exercise machines?
  - E.g. different movements/muscle groups
- Different age groups?
- Clinical populations?
Conclusion

- Reliable
- Valid
- Software limitations
- Practical–knee flexion/extension
THANK YOU!
Correlation Coefficient

- $r = -0.90$
- $r = -0.50$
- $r = 0.00$
- $r = 0.50$
- $r = 0.90$
- $r = 1.00$
Intra-class Correlation Coefficient

Large ICC

Small ICC
Limits of Agreement

Bland-Altman Plot

Difference PEFIR (normal-min) (l/min)

Average PEFIR by two meters (l/min)