Intersession Reliability of Isokinetic Strength Testing in Knee and Elbow Extension and Flexion Using the BTE PrimusRS

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Context: The use of isokinetic dynamometers plays an important role in different settings of sports and medicine. Therefore, high reliability of these devices is required. Objective: The aim of this study was to examine the intersession reliability of the dynamometer BTE PrimusRS relating to the isolated single-joint exercises extension/flexion of the knee and elbow for isokinetic testing. Design: Intersession reliability. Setting: Clinical settings and sports science. Participants: 16 young male students. Intervention: The testing protocol includes 5 consecutive repetitions (concentric/concentric) at a velocity of 60°/s for the exercises. Main Outcome Measures: Raw data of torque curves were used to determine the peak torque. Reliability was evaluated with the intraclass correlation coefficient (ICC), the limits of agreement (LoA), and the bias and the variability of measurements (V). Results: High ICC values (.954–.991) were found for the used exercises. However, the LoAs yielded up to over 16 Nm and the V yielded up to nearly 9% in several testing exercises, indicating poor absolute reliability. Conclusion: The BTE PrimusRS shows good to excellent reliability. However, regarding the absolute measures of reliability, users must decide as experts in their fields whether this reliability is sufficient for their purposes.

Keywords: therapy, single-joint exercise, torque, dynamometer

Isokinetic dynamometers are important in clinical settings, medical laboratories, or in sports science contexts (eg, rehabilitation processes) to analyze performance of muscles and to evaluate training intervention strategies. In those settings, a high reliability of dynamometers and testing methods is required. To evaluate the reliability of isokinetic devices, single-joint exercises for lower and upper extremities, like the concentric knee and elbow extension and flexion, were often used. These exercises were chosen because of their frequent use in the mentioned areas.

Next to established dynamometers (eg, Cybex, Biodex, KinCom) that are used for analyzing and exercising muscular performance only for classical strength exercises, there are also other devices like the BTE PrimusRS (Baltimore Therapeutic Equipment Company, USA) that offers further possibilities to perform occupational exercises. For this dynamometer, a good reliability has already been attested with respect to the assessment of handgrip strength, torque velocity, and wrist-flexion strength.

However, to the best of our knowledge, no investigations have yet addressed the intersession reliability regarding the classical isokinetic exercises. Therefore, the purpose of this study was to examine the intersession reliability of the BTE PrimusRS for single-joint isokinetic exercises of the lower and upper extremities, respectively.

Methods

Participants

Sixteen young male students (age 22.6 ± 2.8 y; height 1.76 ± 0.07 m; body mass 69.7 ± 7.9 kg; body-mass index [BMI] 22.5 ± 2.3) were included in this study. Fifteen subjects were right dominant. Each subject was briefed about the research aims and protocol (according to the Declaration of Helsinki) and signed a written informed consent. Ethical approval for this study was granted by the local ethical committee (No 74/15).

Procedures

Each subject’s body mass and height were measured using a digital body weighing scale with an integrated digital stadiometer (seca 764, Seca GmbH & Co KG, Germany). The BMI was calculated.

The testing of the lower extremities started with a warm-up of 5 minutes of leg cycling on a cycle ergometer (KardiomedBike, proxomed Medizintechnik GmbH, Germany) with a workload of 1.0 W/kg and a cadence of ~70 rpm. Thereafter, the subject was seated in an upright position (with an angle of 80° between upper body and thighs) on the BTE Patient Positioning Chair (Figure 1). The chair was connected to the dynamometer using a special connecting bar (chair tool by BTE) and wheels were fixed with a break to minimize chair movements to increase the stability of the system. The subject’s upper body, waist, and thighs were stabilized using specific straps to control for extraneous body movements.
Regarding the position of the chair and subject in relation to the device, the axis of rotation of the dynamometer was aligned with the axis of the knee joint, using the lateral femoral condyle as bony landmark. The shin pad at the lever arm of the dynamometer was strapped to the distal end of the subject’s tibia. The range of motion of the 1-legged, single-joint knee-extension/flexion movement was set at 90° knee flexion to 0° knee extension.

The subject performed 5 passive repetitions as well as 5 submaximal concentric/concentric repetitions (with about subjectively self-rated 50% of maximal voluntary contraction) at a velocity of 60°/s for each exercise on both limbs to familiarize with the isokinetic testing mode and the particular testing conditions. Then, after a rest of 90 seconds, the subject performed 5 maximal repetitions which were recorded to assess torque data. The mentioned testing procedure was firstly performed with the dominant leg and then with the nondominant leg.

Thereafter, we tested the upper extremities. The subject completed a warm-up of 5 minutes of arm cycling on an arm crank ergometer (Lode Angio, Lode BV Technologies, The Netherlands) using a workload of 0.5 W/kg and a cadence of about 70 rpm. Then, the subject was seated in an upright position (with an angle of 90° between upper body and thighs) on a resistance-training bench with back rest which was positioned in front of the dynamometer. The subject was asked to lean his upper body against the back rest and was then stabilized using a specific strap. Having a neutral position in the gleno-humeral joint, the subject leaned his upper arm against an almost vertical arm rest (15°) and grabbed the handle at the lever arm of the dynamometer. The positioning of the bench and the subject included the proper alignment of the axis of rotation of the dynamometer with the axis of the elbow joint. The range of motion of this 1-armed, single-joint elbow-flexion/extension movement was set at 0° elbow extension to 100° elbow flexion. The precise position of the bench has been documented with the aid of a coordination plate on the ground (see Figure 1).

The procedure of testing the upper extremities was equivalent to the testing of the lower extremities.

With each subject, the testing procedure was performed 2 times at the same time of day (t1, t2) with an intersession interval of 7 days between sessions. To minimize intertester variability, all tests were conducted by the same experienced observer. The BTE PrimusRS was calibrated in accordance with the user manual on the same day once a week.

**Statistical Analyses**

The raw data were exported from the BTE software and analyzed using MATLAB (version 2014b, The Math-Works BV, Natrick, MA), as well as the statistical computer software SPSS (version 22, IBM, Germany). The sampling frequency is predefined by 100 Hz for the BTE.
Reliability of the BTE PrimusRS

In accordance with the methods of Oliveira et al., the peak torque was determined in an average window of 10° around the automatically determined peak torque using MATLAB. The acceleration of the dynamometer approximates 5° to reach the desired angular velocity. Therefore, we excluded the first 5° of the torque curve. Hence, the isokinetic range of motion for the knee and elbow was 85° and 95°, respectively. After checking for normal distribution (Kolmogorov-Smirnov test), intersession reliability was assessed with the intraclass correlation coefficient (ICC2,1), a 2-way random effects model with single and average measure reliability (absolute agreement). ICC2,1 values are classified as follows: .0–.40 poor, .40–.59 fair, .60–.74 good, and .75–1.00 excellent. Moreover, the bias (mean of all differences between the 2 measurements on the same subject) and the limits of agreement (LoA) is the reference interval to the bias; mean ± 1.96 × SD were calculated. Additionally, the variability of measurements (V) between the test and the retest was calculated. V is calculated as the percentage of those intersession differences regarding the mean of both measurements for each individual measured value as indicated by Mayer et al.:

\[
V = \frac{\text{abs}(\text{measurement A} - \text{measurement B})}{\text{[(measurement A + B)/2]}} \times 100 \%
\]

Results

Table 1 presents the means and standard deviations as well as the values of the ICCs, bias, and LoAs of the knee-extension/flexion exercises and elbow-flexion/extension exercises for the evaluation method PTØ3 for all 16 participants.

The ICC values indicate excellent reliability for the exercises knee extension/flexion and elbow flexion/extension. The values of bias and LoAs regarding the PTØ3 are depicted in the Bland-Altman plots in Figure 2 and listed in Table 1. Regarding the results, the knee exercise shows higher LoAs as compared with the elbow exercise.

The intersession variability of measurements (V) regarding PTØ3 is included in Table 1. V of PTØ3 ranged between 3.03% ± 3.40% and 8.82% ± 5.05%.

Discussion

The aim of our study was to examine the intersession reliability of single-joint isokinetic exercises of the lower and upper extremities using BTE PrimusRS which has, to the best of our knowledge, not been examined yet. The main finding is that all ICC values indicate good to excellent reliability (see Table 1). However, regarding the absolute measures of reliability, we have to report considerable variations with LoAs up to over 16 Nm (PTØ3, knee flexion) and V up to nearly 9% (PTØ3, elbow extension), which could classify to very high values and indicate occasionally poor reliability for the exercises. Thus, the use of the mentioned exercises of the BTE must be considered critically due to the high variability of measurements. Subtle intervention effects, as usually observed in older people, might not be detectable. Moreover, bilateral isokinetic testing is an assessment tool commonly used to quantify muscular (im)balance after orthopedic injuries. Here, bilateral deficits smaller than 10% cannot be assessed precisely. However, aiming to detect bigger differences (like in the current investigation of Jindal et al., who have used comparable exercises to investigate the influence of hypermobility on strength in healthy young adults with the BTE PrimusRS), the reliability of the exercises can be considered sufficient.

Limitations of the BTE PrimusRS

One limitation of the system assessing isokinetic strength is that no gravity correction is available. Hence, for exercises in the vertical plane, the torques are the sum of the muscular force and the gravitational force due to the mass

Table 1: Intersession Reliability of the Average Torque of the Best 3 of 5 Repetitions (PTØ3) for the Knee-Extension/Flexion Exercise and Elbow-Flexion/Extension Exercise at the BTE PrimusRS

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Pre (Mean ± SD), Nm</th>
<th>Post (Mean ± SD), Nm</th>
<th>ICC</th>
<th>95% CI</th>
<th>Bias, Nm</th>
<th>LoA, Nm</th>
<th>V, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee extension left</td>
<td>142.0 ± 15.3</td>
<td>140.3 ± 19.0</td>
<td>.970</td>
<td>.917–.989</td>
<td>−1.696</td>
<td>11.025</td>
<td>3.37 ± 4.04</td>
</tr>
<tr>
<td>Knee extension right</td>
<td>144.6 ± 12.9</td>
<td>145.0 ± 15.1</td>
<td>.954</td>
<td>.867–.984</td>
<td>0.429</td>
<td>11.552</td>
<td>3.03 ± 3.40</td>
</tr>
<tr>
<td>Knee flexion left</td>
<td>100.0 ± 25.8</td>
<td>99.8 ± 28.3</td>
<td>.984</td>
<td>.954–.994</td>
<td>−0.206</td>
<td>13.370</td>
<td>5.96 ± 5.37</td>
</tr>
<tr>
<td>Knee flexion right</td>
<td>100.3 ± 25.8</td>
<td>102.6 ± 27.7</td>
<td>.974</td>
<td>.927–.991</td>
<td>2.278</td>
<td>16.173</td>
<td>6.00 ± 5.41</td>
</tr>
<tr>
<td>Elbow extension left</td>
<td>39.4 ± 12.2</td>
<td>38.5 ± 11.5</td>
<td>.971</td>
<td>.918–.990</td>
<td>−0.895</td>
<td>7.685</td>
<td>8.82 ± 5.05</td>
</tr>
<tr>
<td>Elbow extension right</td>
<td>41.1 ± 11.7</td>
<td>40.5 ± 12.7</td>
<td>.980</td>
<td>.944–.993</td>
<td>−0.594</td>
<td>6.572</td>
<td>6.22 ± 5.07</td>
</tr>
<tr>
<td>Elbow flexion left</td>
<td>44.5 ± 15.9</td>
<td>43.9 ± 16.6</td>
<td>.991</td>
<td>.974–.997</td>
<td>−0.646</td>
<td>6.010</td>
<td>5.75 ± 4.86</td>
</tr>
<tr>
<td>Elbow flexion right</td>
<td>47.2 ± 15.9</td>
<td>45.5 ± 16.7</td>
<td>.988</td>
<td>.961–.996</td>
<td>−1.678</td>
<td>5.984</td>
<td>6.42 ± 5.04</td>
</tr>
</tbody>
</table>

Abbreviations: ICC, intraclass correlation; CI, confidence interval; LoA, limit of agreement; V, variability of measurements.
**Figure 2** — The Bland-Altman plots show the average peak torques of the best 3 of 5 repetitions (PT₁₀) for the knee-extension/flexion exercise and elbow-flexion/extension exercise at the BTE PrimusRS. *Note.* Solid line shows bias; dashed lines shows limits of agreement.
of the limb and the lever arm. Another constraint is that the system is not able to quantify torques greater than 162.76 Nm in the isokinetic modus and only a maximum of 20 repetitions is possible. Because of a given slackness at the leverage point of the lever arm, the torque curves include artifacts in the reversal points of the movement.

In conclusion, the BTE PrimusRS has a good to excellent reliability regarding ICC values. The absolute reliability of this system is worse. Therefore, the users must decide as experts in their fields about its utilization based on the specific conditions and aims of the study, the research protocol, and/or the demands on precision regarding specific diagnoses in the clinical setting.

References


