WITHIN- AND BETWEEN-SESSION RELIABILITY FOR THE QUANTIFICATION OF THE THIGH MUSCLES CO-ACTIVATION INDEX DURING ISOMETRIC CONTRACTIONS

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INTRODUCTION

Co-activation is the simultaneous activation of agonist and antagonist muscle groups around a joint, which contributes to joint stability and movement efficiency [1]. Co-activation becomes very important during ambulation and balance particularly around the knee. While certain levels of co-activation are normal in healthy populations, increased or reduced levels of co-activation may be associated with neuromuscular problems [2]. However, the wide range of methodological approaches for the quantification of co-activation makes comparison across studies and populations difficult. Most of the techniques that quantify co-activation index (CI) can be grouped within four categories, with normalization of each muscle with its respective maximum contraction to be considered the most advanced [2]. Nonetheless, there are still inconsistencies in smoothing techniques for the EMG signal. Root mean square (RMS) is the most commonly used smoothing approach [3] but the choice of RMS parameters may affect the reliability and meaning of results within and between sessions. Therefore, the purpose of the present study was to determine within- and between-session reliability of different methodological approaches for the quantification of the CI of the thigh extensor and flexor muscles of the knee during maximum voluntary isometric contractions (MVIC).

METHODS

Six healthy subjects with prior experience generating isokinetic contractions in a Biodex dynamometer (3 men and 3 women; 27.7±5yrs, 176.3±12cm; 81.8±14kg) completed two sessions of five knee MVICs. Surface electrode pairs were placed over the accessible segments of the quadriceps muscle of the dominant leg (vastus medialis, rectus femoris, and vastus lateralis) and the hamstring muscle groups (lateral hamstrings, medial hamstrings) according to the SENIAM guidelines. Subjects were secured to the Biodex chair with knee and hip joint angles of 60° and 120°, respectively. The dynamometer was aligned with the anatomic knee axis and the torque arm secured to the distal shank. Subjects performed one knee flexion MVIC followed by four extension MVICs with a minute of rest between each contraction. All subjects were retested to assess between–session reliability with at least 3 days between sessions.

Torque and EMG signals were captured at 1kHz. Both peak torque (PT) and PT normalized to body weight (nPT) were extracted for analysis. The EMG signals were band-passed filtered (10 to 450Hz), corrected for zero offset, full-wave rectified, and normalized to MVIC. CIs were calculated based on the a) amplitude of the raw EMG signal, and b) root mean square (RMS) by calculating the quotient between the average EMG activity of the 2 antagonist and 3 agonist muscle groups. Five RMS methods were compared: smoothing the entire burst in windows of 20 and 50msec and smoothing a window of 20, 50, and 500msec around the PT (Figure 1). Intraclass correlation coefficient (ICC)
analysis was used to assess the consistency of the different calculation approaches. Coefficients of variation (CV) were also calculated to determine within- and between-session variability.

RESULTS AND DISCUSSION

Torque (PT=406±139N*m; nPT=1.64±0.26) was highly reliable within- and between-sessions (ICC 0.982 and 0.958, respectively), which implied that subjects were able to reproduce their PT at both sessions and that any variation in CI values were not due to variations in torque output. CI values ranged from 13.4 to 16.1, with the calculations employing peak amplitude across the entire burst giving the highest values and methods using RMS around the PT producing the lowest values (Table 1).

Within-session

ICC analysis of the CI quantification approaches (Table 1) revealed that within-session coefficients were greater than 0.80, with most values greater than 0.90, while within-session CV values ranged from 8.6% to 21.6%. Within-session results indicated that quantification of CI was highly reliable for all approaches, with the 500ms-window yielding the most reliable and by far the least variable CI.

Between-session

ICC values for the between-session analysis ranged from 0.571 to 0.796, while CV values ranged from 24.9% to 30% (Table 1). The RMS approach in windows of 20 and 50ms throughout the entire burst as well as the RMS approach at a 500ms window around the PT produced higher ICC values and less variability than the other tested approaches. Between-session ICC values are consistently lower than within-session ICC values across all CI approaches. The opposite holds truth for CV values with between-session values to be consistently higher than within-session CV values.

CONCLUSIONS

The striking finding of the present study was the markedly lower reliability and the higher variability of the CI between-sessions in comparison to the within-session CI calculations. Small shifts in EMG electrode placement between sessions explain some of the differences. Also, the submaximal co-contraction of the hamstring muscles during knee extension could allow greater variability in the motor unit recruitment and firing frequency [4].

RMS at 500ms around the PT appeared to be a more reliable and less variable approach for the quantification of the CI. A possible explanation is that a 500ms window eliminated much of the motor unit size recruitment and firing rate variability that occurred across the entire contraction time or suppress potential artifacts that may occur using window sizes smaller than 500ms.

REFERENCES

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Table 1: Within- and between-session reliability and variability for the different quantification methods of the co-activation index.

<table>
<thead>
<tr>
<th>CI (mean±SD)</th>
<th>Within-session</th>
<th>Between-session</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI</td>
<td>CV (%)</td>
<td>ICC</td>
</tr>
<tr>
<td>Amplitude</td>
<td>16.1 (10.1)</td>
<td>14.2</td>
</tr>
<tr>
<td>RMS 20ms @PT</td>
<td>13.5 (8.0)</td>
<td>21.6</td>
</tr>
<tr>
<td>RMS 50ms @PT</td>
<td>13.5 (8.6)</td>
<td>19.9</td>
</tr>
<tr>
<td>RMS 500ms @PT</td>
<td>13.4 (8.8)</td>
<td>8.6</td>
</tr>
<tr>
<td>RMS 20ms</td>
<td>14.9 (9.9)</td>
<td>17.3</td>
</tr>
<tr>
<td>RMS 50ms</td>
<td>14.8 (10.3)</td>
<td>15.2</td>
</tr>
</tbody>
</table>

* CI = Coactivation Index, CV = Coefficient of Variation, and ICC = Intraclass Correlation Coefficient.