PROPOSING A MINIMAL DATA SET TO QUANTIFY QUASI-STATIC SITTING POSTURAL STABILITY IN INDIVIDUALS WITH SPINAL CORD INJURY

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INTRODUCTION

There is a lack of research on sitting stability in individuals with spinal cord injury (SCI) using quantitative methods. Time and frequency domain measures are commonly applied to quantify the displacement, velocity, area, and frequency characteristics of the centre of pressure (COP) fluctuation. Yet it is still not clear why one measure should be superior in differencing postural stability in healthy and pathological populations. This study aimed to determine a minimum data set of postural measures to quantify sitting postural stability in individuals with SCI.

METHODS

Fourteen individuals (age=41.1±14.7 yrs; height=1.8±0.08 m; weight=83.1±23.3kg) with SCI (lesion level=C3-L1; AIS=A-D; time since SCI=4.4±6.3 yrs) and 14 healthy matched controls volunteered to participate in the study. During a laboratory assessment, they sat on an instrumented seat that has no backrest, with their feet resting on two forceplates embedded into the floor, and maintained two 60-second short-sitting positions: 1) with both hands resting on their thighs (supported sitting) and 2) with both shoulders flexed at 70° and abducted at 45° (unsupported sitting). Reaction forces were recorded at a sampling frequency of 600 Hz. The resultant (RD) COP time series, computed from the tri-axial components of the combined reaction forces, was low-passed filtered (5 Hz) and then down-sampled (300 Hz) before analysis. Seventeen COP measures based on time and frequency series, structured into five types of measures, were computed (Table 1) [1]. A total of 39 COP measures were obtained for each sitting task since isolated measures for the unsupported sitting position were proposed as a minimal data set when quantifying quasi-static sitting postural stability, especially among individuals with SCI.

Table 1. Summary of the COP-related outcome measures.

<table>
<thead>
<tr>
<th>Types of measure</th>
<th>Outcome measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-Domain Distance measures</td>
<td>mean distance: average distance from the mean COP (mm)*</td>
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<tr>
<td></td>
<td>RMS distance (mm)*</td>
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<td></td>
<td>Range: maximum distance between any two points (mm)*</td>
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<td></td>
<td>mean velocity: average velocity of the COP (mm/s)*</td>
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<tr>
<td>Area measures</td>
<td>95% confidence circle area (mm²)</td>
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<td></td>
<td>95% confidence ellipse area (mm²)</td>
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<tr>
<td>Hybrid measures</td>
<td>Sway area (mm²/s)</td>
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<tr>
<td></td>
<td>Mean frequency (Hz)*</td>
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<tr>
<td></td>
<td>Fractal dimension</td>
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<tr>
<td></td>
<td>Fractal dimension based on the area-CC</td>
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<tr>
<td></td>
<td>Fractal dimension based on the area-CE</td>
</tr>
<tr>
<td>Frequency Domain measures</td>
<td>Total power frequency (Hz)*</td>
</tr>
<tr>
<td></td>
<td>Median power frequency (Hz)*</td>
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<tr>
<td></td>
<td>95% power frequency (Hz)*</td>
</tr>
<tr>
<td></td>
<td>Centroidal frequency (Hz)*</td>
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<td></td>
<td>Frequency dispersion (Hz)*</td>
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</tbody>
</table>

*Computed based on resultant (RD) time series as well as on the anteroposterior (AP) and mediolateral (ML) time series.

Pearson correlation coefficients quantified the association between the 17 outcome measures for each task in each group on each directional component (a total of 408 correlations by group). The COP measures that strongly correlated (≥0.90) were organized under correlation subgroups and were judged to provide the same information. Then, the strongest correlated variable (with the mean highest r and the great number of r) within each correlation subgroup was selected as the most representative measure. Then, all uncorrelated measures found had to be sufficiently discriminative within themselves (r<0.70), between groups and tasks to be included in the minimal data set. Therefore, a two-way ANOVA was also computed to confirm these differences between groups and tasks. Correlation coefficients were also used to verify the influence of AP and ML components on resultant COP outcome measures.

RESULTS

Distance and area COP measures were highly correlated with each other but not to frequency and hybrid measures. Mean distance and mean velocity were the strongest correlated variable among the 2 correlation groups of distance and area measures on each directional component in both groups. Among the correlation groups of frequency and hybrid measures combined, centroidal frequency was the strongest measure on each component in individuals with SCI, whereas it was the frequency dispersion in healthy controls. The most discriminative uncorrelated measures were linked to frequency and hybrid measures in both groups (sway area and median power frequency in individuals with SCI; centroidal frequency in healthy controls). In both groups, the 11 measures with directional components showed stronger correlations between RD and AP component than between RD and ML component. Individuals with SCI also showed stronger correlations between the RD and ML component than healthy controls.

DISCUSSION & CONCLUSION

Mean distance, mean velocity, area sway, centroidal frequency, median power frequency and frequency dispersion are proposed as a minimal data set when quantifying quasi-static sitting postural stability, especially among individuals with SCI. These measures should be reported for all directional components whenever applicable, as both AP and ML activity independently contribute to the resultant COP outcome measures.

REFERENCES


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