An adapted optical approach to measure lumbar-specific spinal shrinkage

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Summary

This adapted optical approach to measure spinal shrinkage uses a simple and fast "against-the-wall" strategy for posture control, with lumbar- and thoracic-specific measures.

Introduction

The cumulative effects of spinal loading can be assessed by measuring spinal shrinkage (change in length) using stadiometry [1]. However, traditional stadiometry protocols only measure total spine shrinkage, and their complex posture control strategies (using sensors and apparatus) require a pre-training session. Objectives: To test the measurement properties (repeatability, test-retest reliability, responsiveness) of a simplified protocol, with no separate training, that provides lumbar- and thoracic-specific measures.

Methods

Participants (n = 20) performed 2 sessions 3-14 days apart for test-retest reliability testing. Stadiometric (indicator over the head) and optical measures at four spine levels (S1, T12, T8, C6) were performed while standing in a standardized 4-point posture against the wall [2] (Figure 1). Ten hop-on-hop-off repeated measures were taken in 3.5 min. (on exhale), using pre-recorded instructions, at 4 time-intervals: (1) to familiarize the participant (T0), (2) as baseline measures (T1), (3) after 20-min unloading in side-lying position (T2) and (4) after 20-min loading in standing with a 10-kg backpack (T3).

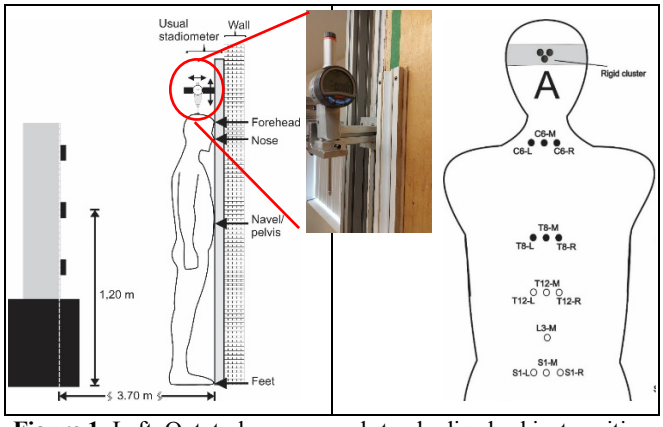

Figure 1: Left: Optotrak camera and standardized subject position against the wall. Right: Markers at different spine levels, as needed.

The difference between measures at different time points (T2 - T1 and T3 - T2), corresponding to the two physical exposures (20 min. side-lying and 20 min. loading), was calculated to produce change scores (ΔIndicator, ΔC6, ΔT8, ΔT12, ΔS1) corresponding to spinal lengthening or shrinkage.

Results and Discussion

The Δindicator scores confirmed ($P < .05$) that side-lying rest induced a 3.0 ± 2.5 mm spine lengthening while the 10-kg standing tasks induced a -3.1 ± 2.0 mm shrinkage.

The head flexion, thoracic kyphosis and lumbar lordosis mean angles (across 10 trials) did not change between sessions 1 and 2, nor between T0 and T1 series. The corresponding SD values (across 10 trials) ranged between 0.5 and 1.0°, supporting the "against-the-wall' posture control strategy.

The behavior of the three juxtaposed skin markers (at each spine level) was the same, justifying averaging the scores. The following results (repeatability, reliability, responsiveness) were the same whether using one or three markers. The results below are for the average of three markers as, in the event of marker loss, the use of three markers is recommended.

Repeatability. The standard deviation (SD), computed across the 10-trial series, ranged between 1.5 and 2.0 mm for the indicator, between 0.8 and 1.4 mm at C6, T8 and T12 spine levels and up to 1.7 mm at S1. These values are higher than the 0.5 mm criterion (determined arbitrarily) but are within the range of values reported in previous studies.

Test-retest-reliability. Across the various measures (ΔIndicator, ΔC6, ΔT8, ΔT12, ΔS1), intraclass correlation coefficients [ICC(2,1); range: 0 to 0.36] were poor while standard errors of measurement (SEM; range: 1.0 to 2.1 mm) were good. Interestingly, using optical measures, it was possible to compute shrinkage corresponding to each trunk segment (ΔC6-S1, ΔT8-S1, ΔT12-S1), leading to higher ICCs (0.41 to 0.43) but also slightly higher SEMs (1.6 to 2.3 mm).

Responsiveness to side-lying and 10-kg physical exposure. Strong Cohen'd effect sizes were observed for the indicator (d = 1.20 & 1.55), at C6 (d = 1.87 & 3.26), T8 (d = 2.32 & 2.29) and T12 (d = 1.30 & 3.17), but not at S1 (d = 0.43 & 0.72). For trunk segments, effect sizes were lower (0.52 to 1.23).

Conclusions

The simplified "against the wall" repositioning strategy produced repeatable scores comparable to those of previous studies using traditional stadiometry protocols requiring an instrumented device. No separate training session is required, improving feasibility (time, cost). The optical approach gives satisfactory results, with the exception of relative reliability (ICCs), which is attributed to "change" scores.

References

[1] Eklund J and Corlett EN (1984). *Spine*, **9**: 189-194.
[2] Wing P et al. (1992). *Spine*, **17**: 761-766.