Postural assessment, Part Two: Deviation for sense of, and actual alignment

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ABSTRACT

Introduction: Accurate sensing of the body position in space is important for safe and mechanically effective interaction with the environment. Clinical evidence however suggests that a client’s sense of postural alignment differs from their actual alignment, which may influence the accuracy of postural repositioning during participation in activities of daily life.

Objectives: The aim of this quantitative descriptive study was to investigate the difference between sense and actual postural alignment during sitting and standing positions, with the anatomical landmarks as reference points for measurement from anterior and lateral views.

Methods: Ten health care clinics in the Free State towns of Botshabelo and Thaba N’chu, were randomly selected and 95 patients participated in the study. Measurements consisted of (a) a biographical questionnaire, (b) assessment of actual postural alignment, and (c) assessment of sensed postural alignment. Assessment of actual postural alignment was done by using the Photographic Method of Postural Assessment (P-MPA), during which the actual (real) distance on photos was established by calculating the ratio of measured/real distance x distance from plumb line for each photo. A clinical significant difference from the reference point as measured on the photo was set at 10mm. The sense and actual deviation, for sitting and standing were compared by means of 95% confidence intervals for median differences.

Results: Results show statistical and clinically significant differences for sense and actual deviations from the plumb line for lateral views for all anatomical landmarks, in both sitting and standing positions. With the exception of a clinical significant difference at the nose landmark in anterior view, results show no other statistical or clinical significant differences for anterior sitting or standing.

Recommendations: The authors recommend that follow up studies investigate postural repositioning during motion and in addition to speed and direction, also test the degree to which discrepancy between sense and actual values occurs.

Conclusion: Increased awareness by health care professionals and educators of the discrepancy between sensed and actual postural alignment, in anterior and lateral views, may benefit the planning of intervention programmes aimed to enhance safe and meaningful occupational performance.

Key words: Postural alignment, sense of posture and actual posture

INTRODUCTION AND LITERATURE REVIEW

Health care practitioners treat clients with postural deviations by following (among others) an educational approach1,2,3 to correct postural alignment in order to perform safe4,5, precise and accurate6,7 movement during activities of daily life8, and to enable mechanically effective movement9. The Posture Committee of the American Academy of Orthopaedic Surgeons8, defines posture as “the relative arrangement of the parts of the body”, and state that normal posture refers to muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity irrespective of the working of resting positions of these structures. Kendall9 regards postural alignment as ideal when specified anatomical landmarks align with a plumb line, representing a vertical line of gravity through the centre of gravity. This functions as the single point around which the mass of the body is equally distributed.

Sensing the body’s location in external space is important for interacting with the environment.10 Research findings on the accuracy of sensed postural alignment in literature are mainly focussed on the sense of single joint positions and the influence of external factors on joint positions11,12, as well as matching sensed posture of opposite joints13,14. Most studies on the accuracy of sensed posture have been performed at the knee joint15-17. Results from a study18 that investigated the difference of sensed posture using open kinetic chain and closed kinetic chain (CKC) found a mean error of 5,5° and concluded that the mean error in sensed posture is less in CKC. Cheuh-Ho Lin et al.19 proved an insignificant mean error of 0.6° for sensed posture in healthy ankles. Olson, et al.20 found that contralateral assessment showed a greater mean error than ipsilateral assessment. Brindle et al.21 states that visual feedback enhances sensed posture, while Gibson22 proved vision to be more dominant than touch and proprioception. Far less research evidence is available on sense of position of the shoulder and elbow joints. Correlation between sensed posture position and sensed posture error23 between shoulder and elbow joint indicates similar errors in sensed posture and further indicate that sensed posture error decreases nearing end-range of motion. King, Harding and Karduna24 further found no significant differences in sensed posture between left and right upper extremity joints, and proved that the mean error for the shoulder joint was greater than the elbow joint.

Unpublished research findings25 indicate that whole body posture (multi-joint), sense of posture is more accurate in anterior planes than in the lateral planes, and that the number of participants with actual deviation in posture is more than the number of participants who sensed a deviation in their postural alignment.
This finding implies that participants who actually deviate from the plumb line in their postural alignment, often do not know the extent to which they deviate.

During clinical intervention it is implicitly assumed that a client is able to accurately perceive and interpret their own postural alignment\(^{25}\) in relation to ideal alignment, and that posture behaviour adjusts accordingly\(^{26-29}\) during the performance of activities of daily life. The researchers of the current study argue that postural intervention may be more efficient if the differences between sensed and actual posture is known, and that the differences are considered in occupational assessment and intervention programmes. Attempts to improve on current postural intervention strategies should therefore note possible differences between sensed and actual postural alignment, in order to optimise intervention with combined modalities of education and proprioceptive intervention strategies.

In the absence of published research evidence that report on the sense of postural alignment on a multi-joint level\(^{30,31}\), as they compare to actual alignment, this study aimed to investigate the difference between sense of postural alignment and the actual postural alignment in sitting and standing, from both anterior and lateral views, for specified anatomical landmarks.

**METHODOLOGY**

**Study Design**

A quantitative cross-sectional descriptive design was selected to perform this study. Ethical clearance was obtained from the Health Sciences Research Ethics Committee at the University of the Free State (HSREC 171/2016/1415). Permission to conduct the study was obtained from the District Manager, Mangaung Metro and the Free State Provincial Health Research Committee.

**Sampling**

Of the 26 public health care clinics in Botshabelo and Thaba N’chu, ten clinics were randomly selected and a convenient sample of 10 patients per clinic participated in the study if they met the specified inclusion criteria. Patients were included if they were able to assume a sitting and sitting position for 2 minutes, willing to participate in the study, and able to speak English, Afrikaans or Sesotho. Patients were excluded if they reported hearing impairments or a spinal cord trapped nerve, or if they were diagnosed with acute musculoskeletal injury and/or musculoskeletal pathology such as cerebral palsy, scoliosis or radiculopathy.

**Data collection**

Prior to the day of data collection, each clinic was visited by a trained fieldworker (qualified occupational therapist) who informed the clinic personnel about the procedure for data collection, where after a suitable venue was located at each respective clinic for this purpose. On the day of data collection all patients who attended the clinic were informed about the study, and signed informed consent was obtained to participate in the study. The field worker provided the participant with information regarding the procedure of postural assessment.

Measurement comprised three parts namely: a biographical questionnaire, measurement of actual postural alignment and sensed postural alignment. Actual- and sensed postural alignment were assessed using the Photographic Method of Postural Assessment (P-MA)\(^{32}\). The actual (real) distance on photos (Figure 2 page 40).

**Method**

**Assessment: marking of anatomical landmarks**

The participant was requested to assume a comfortable standing position, for the marking of the following landmarks by making use of a 5mm reflective sticker:

- lateral view: anterior aspect of lateral malleolus, mid-knee, greater trochanter, acromion and external auditory meatus (ear lobe);
- anterior view: mid-heels, mid-knees, navel and nose.

**Assessment of posture**

The participant assumed a position 1 meter behind the plumb line, with the plumb line aligned with the anterior aspect of the lateral malleoli for the standing position, and with the plumb line aligned with mid heels for the anterior position. The participant was asked to assume his/her most natural standing and sitting position. For the taking of measurements, the field worker assumed a position 2 metres from the plumb line. A photo was taken by the field worker using a smartphone that was fixed on a tripod at a height of 950mm. After the photo had been taken the participant’s sense of posture was assessed by asking the participant to indicate their sensed deviation from the plumb line on a ruler for all the anatomical landmarks (Figure 2 page 40).

Measurements were then documented on the data form (Figure 2) for sitting and standing in both lateral and anterior views. At the end of each day each photograph was printed in A4 size, after which each participant’s actual deviations from the plumb line were measured with a ruler with increments in millimetres, and transferred to data forms.

The actual (real) distance on photos was established by calculating the ratio of measured/real distance x distance from plumb line for each photo\(^{32}\). A clinical significant difference from the reference point as measured on the photo was set at 10mm\(^{33}\). The coding was done by the researchers, followed by data analysis. Descriptive statistics, namely frequencies.
**SENSE**

Procedure

Participant number:  

Anterior views:
Ask participant if anatomical landmark is **left or right** of the line plumb line

Lateral views:
Ask participant if anatomical landmark is **anterior or posterior** of the line plumb line

Ask participant to **indicate how much the deviation** -

Document findings in the columns below

<table>
<thead>
<tr>
<th>VIEW</th>
<th>SITTING</th>
<th>STANDING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANTERIOR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deviation from plumb line (participant indicates)</td>
<td>Sticker to the left of plumb line – tick here</td>
<td>Sticker to the right of plumb line – tick here</td>
</tr>
<tr>
<td>Mid heels</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Mid knees</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Navel</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Nose</td>
<td></td>
<td>None</td>
</tr>
</tbody>
</table>

| **LATERAL** |         |          |
| Deviation from plumb line (participant indicates) | Sticker anterior of plumb line – tick here | Sticker posterior of plumb line – tick here |
| Lat malleolus |         | None |
| Mid knee |         | None |
| Gr trochanter |         | None |
| Acromion |         | None |
| Ear lobe |         | None |

**Table I** (page 41) depicts all 95 participants' data for sensed and actual (real) postural deviation from the plumb line.

For sense: Participants mostly indicated no deviation from the plumb line for the anterior view, though less indicated no deviation for the lateral view. As can be seen in the range for sense (Table I, page 41) there were participants who did indicate deviations.

For actual: The pattern of deviation differed from sense as can be seen in Table I, page 41.

Statistical significant differences were found at all the anatomical landmarks for the lateral view for both sitting and standing between the actual and sensed posture regarding the plumb line. The nose was the only landmark from anterior view that had statistical significant differences between actual and sense per participant, though no clinical significant differences were found at this landmark. Clinical significance was seen as 10mm for this study, therefore all the lateral view landmarks, showed clinical significant differences for both standing and sitting.

**Table II** (page 42) reports on results for participants who sensed a deviation of posture: their sensed and actual deviations are stated.

In order to determine by how much participants’ sensed and actual deviations differed, 95% confidence intervals for the median difference between actual and sense measurements were calculated. A statistical significant difference was indicated in Table II when it occurred (see the footnote at Table II). When sensed deviation oc-
Table I: Posture deviation (n=95)

<table>
<thead>
<tr>
<th>View</th>
<th>Anatomical landmarks</th>
<th>Sitting</th>
<th>Percentage indicated no deviation</th>
<th>Standing</th>
<th>Median Deviation from plumb line in mm (range)</th>
<th>Percentage measured no deviation</th>
<th>Median Deviation from plumb line in mm (range)</th>
<th>Percentage measured no deviation</th>
<th>95% Confidence Interval for the median difference (in mm)</th>
<th>Sensed posture deviation</th>
<th>Actual posture deviation</th>
<th>Sense - Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-knee</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0(-30–+20)</td>
<td>73.7</td>
<td>-</td>
<td>0(-35.7–+5.7)</td>
<td>88.4</td>
<td>[0 ; 0]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navel</td>
<td></td>
<td>0(-30–+20)</td>
<td>83.2</td>
<td>0(-20–+20)</td>
<td>81.1</td>
<td>0(-49.4–+37.0)</td>
<td>58.9</td>
<td>0(-65.2–+61.7)</td>
<td>43.2</td>
<td>[0 ; 0]</td>
<td>[0 ; 7.0]</td>
<td></td>
</tr>
<tr>
<td>Nose</td>
<td></td>
<td>0(-30–+30)</td>
<td>73.7</td>
<td>0(-30–+40)</td>
<td>75.8</td>
<td>0(-72.7–+92.1)</td>
<td>28.4</td>
<td>0(-72.7–+54.9)</td>
<td>28.4</td>
<td>[5 ; 14.6]*</td>
<td>[5.9 ; 13.5]*</td>
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</tr>
<tr>
<td>Lateral</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-knee</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0(-30–+30)</td>
<td>55.8</td>
<td>-</td>
<td>-26.8 (-135.8–+18.5)</td>
<td>14.7</td>
<td>[17.4 ; 32.9]*</td>
<td>[35.7 ; 53.2]*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater trochanter</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0(-30–+30)</td>
<td>55.8</td>
<td>-</td>
<td>-50.6 (-162.2–+35.7)</td>
<td>9.5</td>
<td>[5.2 ; 27.8]*</td>
<td>[13.2 ; 26.8]*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acromion</td>
<td></td>
<td>0 (-30–+30) (n=94)</td>
<td>67.0 (n=94)</td>
<td>0(-30–+30)</td>
<td>62.1</td>
<td>1.6 (-98.8–+163.6)</td>
<td>26.3</td>
<td>0(-107.1–+109.8)</td>
<td>17.9</td>
<td>[5.2 ; 27.8]*</td>
<td>[13.2 ; 26.8]*</td>
<td></td>
</tr>
<tr>
<td>Ear lobe</td>
<td></td>
<td>0 (-30–+30) (n=94)</td>
<td>55.3</td>
<td>0(-30–+30) (n=94)</td>
<td>51.6</td>
<td>0(-149.3–+132.5)</td>
<td>23.2</td>
<td>-43.0 (-147.1–+91.8)</td>
<td>10.5</td>
<td>[7.7 ; 24.7]*</td>
<td>[25.8 ; 50.2]*</td>
<td></td>
</tr>
</tbody>
</table>

* Statistical significant difference  # Clinical significant difference

Please note that the deviation of posture from the plumb line was indicated as negative when it was left of the plumb line for the anterior view and posterior for the lateral view of the participant. All values are indicated in millimetre.
Table II: Sensed and actual deviation for those whom had indicated deviations when sensing posture

<table>
<thead>
<tr>
<th>View</th>
<th>Sensed</th>
<th>Actual</th>
<th>Sensed</th>
<th>Actual</th>
<th>Sense-Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Median Deviation from plumb line in mm (range)</td>
<td>Median Deviation from plumb line in mm (range)</td>
<td>Frequency</td>
<td>Median Deviation from plumb line in mm (range)</td>
</tr>
<tr>
<td></td>
<td>Sitting</td>
<td>Standing</td>
<td>Sitting</td>
<td>Standing</td>
<td>Sitting</td>
</tr>
<tr>
<td>Mid-knee</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>5.0(-30-+20)</td>
<td>0(-27.0-0)</td>
</tr>
<tr>
<td>Navel</td>
<td>16</td>
<td>-</td>
<td>18</td>
<td>7.5(-20-+20)</td>
<td>0(-14.5-+44.8)</td>
</tr>
<tr>
<td>Nose</td>
<td>25</td>
<td>-</td>
<td>23</td>
<td>5.0(-30-+40)</td>
<td>5.7(-72.7-+50.5)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-knee</td>
<td>-</td>
<td>-</td>
<td>42</td>
<td>10.0(-30-+30)</td>
<td>-31.6(-108.7-+18.5)</td>
</tr>
<tr>
<td>Greater trochanter</td>
<td>-</td>
<td>-</td>
<td>42</td>
<td>10.0(-30-+30)</td>
<td>-56.3(-162.2-0)</td>
</tr>
<tr>
<td>Acromion</td>
<td>32</td>
<td>5.0(-30-+30)</td>
<td>8.4(-98.8-+163.6)</td>
<td>36</td>
<td>5.0(-30-+30)</td>
</tr>
<tr>
<td>Ear lobe</td>
<td>43</td>
<td>10.0(-30-+30)</td>
<td>-11.4(-86.9-+132.5)</td>
<td>46</td>
<td>10.0(-30-+30)</td>
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</tbody>
</table>
| *Statistical significant difference
# Clinical significant difference

Table III: Actual posture deviation measured (only for those who had actual deviations)

<table>
<thead>
<tr>
<th>View</th>
<th>Frequency</th>
<th>Median Deviation from plumb line in mm (range)</th>
<th>Median Deviation from plumb line in mm (range)</th>
<th>Median Deviation from plumb line in mm (range)</th>
<th>Median Deviation from plumb line in mm (range)</th>
<th>95% Confidence Interval for the median difference (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sitting</td>
<td>Standing</td>
<td>Sitting</td>
<td>Standing</td>
<td>Sitting</td>
<td>Standing</td>
</tr>
<tr>
<td>Mid-knee</td>
<td>-</td>
<td>-</td>
<td>11</td>
<td>-</td>
<td>0(-20-+20)</td>
<td>-</td>
</tr>
<tr>
<td>Navel</td>
<td>39</td>
<td>-4.9(-49.4-+37.0)</td>
<td>0(-20-+20)</td>
<td>54</td>
<td>[8.5 ; 13.9]</td>
<td>[8.5 ; 13.9]</td>
</tr>
<tr>
<td>Nose</td>
<td>68</td>
<td>13.3(-72.7-+247.3)</td>
<td>0(-30-+30)</td>
<td>68</td>
<td>[12.2 ; 21.7]</td>
<td>[12.2 ; 21.7]</td>
</tr>
<tr>
<td>Lateral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-knee</td>
<td>-</td>
<td>-</td>
<td>81</td>
<td>-34.2(-135.8-+18.5)</td>
<td>0(-30-+30)</td>
<td>-</td>
</tr>
<tr>
<td>Greater trochanter</td>
<td>-</td>
<td>-</td>
<td>86</td>
<td>-56.3(-162.2-35.7)</td>
<td>0(-30-+30)</td>
<td>-</td>
</tr>
<tr>
<td>Acromion</td>
<td>78</td>
<td>-6.7(-107.1-+109.8)</td>
<td>0(-30-+30)</td>
<td>36</td>
<td>-4.4(-95.7-+109.8)</td>
<td>5(-30-+30)</td>
</tr>
<tr>
<td>Ear lobe</td>
<td>85</td>
<td>-45.5(-147.1-+91.8)</td>
<td>0(-30-+30)</td>
<td>46</td>
<td>-54.7(-138.3-+91.8)</td>
<td>10(-30-30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
| *Statistical significant difference
# Clinical significant difference

For mid-knee standing the sensed deviation was significantly more than the actual (95% CI [6.1 ; 20]). For lateral view when deviation was sensed the actual deviation was statistically significant more than the sensed variation (95% CI [-40.6 ; -11.5]).

Table III above reports on when actual posture deviation occurred, and the actual and sensed are stated and compared by means of 95% confidence intervals.

95% confidence intervals for the median difference were calculated in order to determine by how much participants’ sensed and actual measurements differed. If actual deviation occurred it
always deviated statistically significantly more than sensed deviation for all landmarks, and with the exception of the navel landmark (anterior view, sitting) and mid-knee (anterior view standing). Sense and actual deviations showed clinically significant differences for all the landmarks.

**DISCUSSION**

Good postural alignment provides a basis for effective and safe movement during participation in activities of daily life. The implementation of correct postural alignment in activities of daily life relies largely on accurate sensing of postural alignment and the subsequent repositioning of postural alignment. Literature reports on numerous disciplines’ interest in the field of accuracy studies, and results influencing practices and development of professions such as human factors in aviation, sport performance ergonomics, and management.

This paper reports on five important findings regarding the accuracy of sensing postural alignment. Firstly, a difference occurs in sensing postural deviation from the plumb line between anterior and lateral views for both the positions of sitting and standing, where participants sensed less deviation from the plumb line in the anterior view than the lateral view. In this regard, the role of vision in the readjustment of posture is well described in literature.

In the current study the plumb line fell within the central field of vision of the participant (anterior view). This supports the role of central vision in postural alignment, and consistent with the findings of other investigators, Thomas, Bampouras and Doavan correspondingly report on increased postural sway during smooth visual pursuits in more challenging stance positions, demonstrating the importance of visual inputs on postural sway of adults during quiet stance. Similarly Agostini et al. reiterates that central vision seems to affect mostly the medio-lateral direction of postural sway. In further support of the role of vision in perceiving body position, Gibson found that vision is more dominant than touch and proprioception. Gibson explains if an object was made to merely look large using a lens, while it was being palpated, it also felt large. Findings in literature that also align with results of the present study further report on The Ponzo- and The Mueller-Lyre Illusion stating that illusions occur when the perceptual processes or perceptual constancy are "altered" by a particular situation so that something is seen that does not exist or that is incorrect. The theory of perceptual constancy suggests that we always perceive the same object in the same way, despite the fact that sensations that it creates on our receptors changes dramatically.

This ability to perceive a stimulus as constant despite changes in visual sensation may further relate to participants in the present study’s more accurate interpretation of the plumb line as ‘central’.

Secondly, significant differences were observed at all the anatomical landmarks for the lateral view between the actual and sensed posture regarding the plumb line. Regarding the anterior view for the landmark ‘nose’ (sitting and standing) statistical significant differences were seen between actual and sense per participant, though no clinical significant differences were found.

A third finding from the current study is that, when responses from the participants who sensed deviation from the plumb line (anterior view, standing), were compared to their actual deviation, a statistical significant difference was found at the anatomical landmark of the knee (a weight bearing joint). However, from a lateral view, both statistical and clinical differences were found for all the anatomical landmarks in standing.

In the absence of existing evidence regarding the accuracy of multi-joint postural alignment in sitting and standing, findings from the present study should alert assessment and intervention practices to the discrepancies between sensed and actual postural alignment.

The authors firstly recommend that the distance of deviation from the plumb line be considered an additional aspect in the procedure of assessment and intervention planning to ensure and optimise accuracy in assessment and postural intervention practices.

Secondly, health care professionals and educators are advised to accommodate the discrepancy between sensed and actual postural alignment in the design of educational and intervention programmes. Therefore endeavours to improve on current postural intervention strategies should note the differences between sensed and actual postural alignment, in order to optimise intervention with combined modalities of education and proprioceptive intervention strategies.

Health care professionals practising in the field of postural retraining programmes, should take note that weight bearing joints – functioning in a closed kinematic chain – show a clinically significant difference between sensed and actual repositioning of postural alignment.

The authors recommend that follow up studies investigate postural repositioning during motion and in addition to speed and
direction, also test the degree to which discrepancy between sense and actual values occurs.

CONCLUSION

To our knowledge, this is the first study to report on multi-joint postural alignment and the difference between actual and sense deviation from the plumb line. Results from this study showed statistical and clinical significant differences for sense and actual deviations from the plumb line, for certain anatomical landmarks in standing and sitting positions in the anterior and lateral views. The authors therefore wish to raise awareness among health care workers to accommodate for inaccuracy of postural readjustment in the planning of intervention programmes.

ACKNOWLEDGEMENTS

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REFERENCES


AUTHORS ROLES
• PA Hough conceived the idea for the research, and gave input regarding the development of the protocol, analysis, and writing of this article.
• M Nel gave input during the development of the protocol, did the analysis, and gave input during the writing of the article.

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