CLINICAL TECHNICAL NOTE

Physiotherapist observation of head and neck alignment

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ABSTRACT

Objective: To determine the reliability of physiotherapists’ visual observation of head and neck alignment. Design: An interrater reliability study with an evaluation of concurrent validity using a gold standard. Setting: Physiotherapy Research Laboratory, Princess Alexandra Hospital. Participants: Three physiotherapist raters, one male model exhibiting 53 test positions. Main outcome measures: Assessment of head and neck alignment required rating the direction of deviation (in each of the three planes of movement), and the magnitude of deviation. Results: All three assessors were correct across all domains of direction and magnitude of deviation for only 10 of the 53 test positions. There was a mean of 2 total errors (out of a possible 12) per position. The more planes of deviation involved in a position, the more total errors there were. Most errors were made in the axial rotation (transverse) plane. Where a lateral flexion (coronal) plane of deviation was involved, there were more total errors; however, this plane itself had the fewest number of errors. Positions with a combination of both lateral flexion and axial rotation deviations were often mistaken for a flexion/extension (sagittal plane) deviation. Fewer errors were recorded for positions of 10-degree deviation compared to 5-degree deviations. Conclusions: Visual assessment of head and neck alignment by physiotherapists is of questionable validity for identifying deviations in the order of 5 degrees from neutral. For deviations of 10 degrees in a single plane visual, observation is comparable to other clinically available tools.

INTRODUCTION

Measurement of joint alignment and range of motion is necessary to direct and evaluate the effectiveness of treatments for a diverse range of conditions. Methods used in the clinical assessment of movement, alignment, and range of motion throughout the body include visual observation, goniometry, inclinometer, and tape measure (Clarkson and Gilewich, 1989). Goniometry and visual assessment are commonly used clinically for the measurement of cervical range of motion; however, strong recommendation for the use of any one tool is yet to be made (Jordan, 2000). Contemporary methods used to quantify spinal movement for research include ultrasound or electromagnetic sensor systems and accompanying software, photography or video with digital analysis, and radiography (Claus, Hides, Moseley, and Hodges, 2008; Kuo, Tully, and Galea, 2009; O’sullivan et al., 2006; Straker et al., 2008; Strimpakos et al., 2005; Wills et al., 2007). These are valuable tools; however, application in a clinical context may be limited by either availability or practicality.

Several studies have investigated the use of various goniometers for the measurement of cervical range of motion (Fletcher and Bandy, 2008; Jordan, 2000; Klaber Moffett, Hughes, and Griffiths, 1989; Nilsson, 1995; Youdas, Carey, and Garrett, 1991); however, only a few have examined the ability of physiotherapists’ to visually estimate cervical range of motion (Viikari-Juntura, 1987; Youdas, Carey, and Garrett, 1991). Visual observation is used by physiotherapists in the analysis of movement across many fields of practice, with the manner and extent of

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its use being dependent on the patient’s clinical presentation and therapy goals. In a musculoskeletal context, for example, a patient presenting with pain and restriction of cervical range of motion, the estimation of cervical range of motion in each individual plane would be an important component of clinical assessment to assist identification of causative factors of the pain and restriction and to evaluate the effectiveness of interventions. In contrast, the focus of visual analysis in a neurological context, such as in stroke or brain injury, may be directed toward the relative alignment of body segments, such as the head and neck relative to the trunk. This may involve complex observations assessing several planes of motion simultaneously.

Studies investigating visual observation as measurement tool for the cervical spine have focused on the assessment of range of motion (Viikari-Juntura, 1987; Youdas, Carey, and Garrett, 1991) and assessed each plane and direction of movement independently, finding poor to fair reliability. No studies have investigated the ability of therapists to determine deviations of the head from a reference point. This study aims to examine the accuracy and interrater reliability of visual observation to assess deviations of head position of 5 or 10 degrees relative to a reference point, in combinations of one, two, or three planes of movement.

METHODS

Design

This was an interrater reliability study with an evaluation of concurrent validity.

Subjects

Three physiotherapists, each with greater than 5 years experience in neurological rehabilitation (for example brain injury and stroke) participated as raters, in this study. A 28-year-old male with no restriction of cervical range of motion and no history of cervical spine pathology or previous neurological injury participated as a model for the positions of head and neck deviation.

Measures

Intersense InertiaCube3

The Intersense InertiaCube3 (Virtual Reality Solutions Pty Ltd) was used to measure head alignment. Using portable wireless sensors containing gyroscopes and accelerometers, this equipment measures angular accelerations that can be used to measure changes in angular position with root mean square accuracy of 1 degree in the YAW (transverse) plane of motion, and of 0.25 degrees in the pitch (sagittal) and roll (coronal) planes of motion (www.intersense.com). Sensors did not record translations.

Visual observation

Assessors visually assessed and recorded whether there was a rotational deviation in each of the three planes of motion, where axial rotation referred to a deviation in the transverse plane, lateral flexion a deviation in the coronal plane, and flexion/extension a deviation in the sagittal plane. Assessors also assessed whether the deviation was of 5 degrees or 10 degrees in magnitude, chosen as representative of standard error and minimal detectable change for other measurement tools (Fletcher and Bandy, 2008; Jordan, 2000; Klaber Moffett, Hughes, and Griffiths, 1989; Nilsson, 1995). Hence for each assessment trial, the assessors had four pieces of information that they each needed to record. When an assessor correctly identified whether there was a deviation or not in each of the three planes and correctly identified the magnitude of deviation, this response was classified as being “completely correct” for that assessor.

A composite measure of deviation was also employed using the scaling of (i) aligned; (ii) deviation in one plane; (iii) deviation in two planes; (iv) deviation in three planes.

Procedure

The subject was seated on a wooden-backed chair with feet fully supported on the floor. To further maintain an erect sitting posture, the subject’s thoracic spine was attached to the back of the chair using double-sided tape. A rubber latex (swimming) cap was placed over the subject’s head, secured in place using rigid sports tape and the Intersense InertiaCube3 sensor attached to the top (peak) of the subject’s head (Figure 1a). The subject’s head was then positioned in an “ideal” or neutral alignment that was agreed upon by all three assessors. This was calibrated as the “zero” starting position by the software program supporting the Intersense equipment.

Every combination of deviation in both directions of each plane of movement (6 uniplanar, 12 bplanar, and 8 triplanar) was modeled once in the magnitude of 5 degrees, and once in the magnitude of 10 degrees, creating a total set 53 head positions, including one neutral position of no displacement. None of the head positions modeled contained a combination of 5- and 10-degree magnitudes of deviations in different planes.
Each position was modeled by the subject once only and was rated by all three assessors before the next position was modeled according to a computer-generated random number sequence. When the subject assumed a head position, the first assessor viewed the subject in a face-to-face position from between two partitions arranged directly in front of the subject. Assessors 2 and 3 then similarly proceeded through the partitions one by one to make their assessments. The partitions were used to standardize the viewing position and prevent assessors from seeing the real-time biofeedback display visible to the model (Figure 1b). Throughout the study, each assessor remained blind to the observations recorded by the other assessors. A rest period of 30 seconds was given to the model between each position and 5 minutes’ rest between blocks of 15 positions.

To ensure the subject accurately held each position, “real-time” biofeedback was provided to the subject by the Intersense on a laptop display positioned directly in front of the model (Figure 1a, b). This feedback displayed the head position of the model in all three planes of movement, with data updated at a rate of 40 Hz. For an assessment to be valid, the subject had to maintain the head in the appropriate position within ±1 degree of the intended position. If the model deviated outside this range, the trial ceased, the model was provided with an additional brief rest, and the position was attempted again. Demonstration of the model’s position with 5 degrees of deviation in one, two, and three planes is demonstrated (Figure 2).

This study was approved by the human research ethics committee of the Princess Alexandra Hospital.

Analysis

Aim 1—Validity
Observations recorded by each assessor were classified as either completely correct or not completely correct. The proportion of assessments that were completely correct or with one or more errors was calculated. The number of errors per assessment of a position made by each assessor was also calculated. Poisson regression was used to examine whether the presence of each individual plane of deviation, the total number of planes of deviation, or the magnitude of movement involved impacted upon the total number of errors in assessment of the positions modeled. This approach was also used to examine the effect of the plane of deviation and magnitude of deviation on the number of errors made by assessors. Each of these outcomes can be described as count (discrete, non-negative) data with a Poisson distribution for which Poisson regression models are designed to analyze.

Aim 2—Reliability
The interrater reliability of using the composite measure of deviation developed for this study was assessed using the kappa statistic for multiple raters (Fleiss, Nee, and Landis, 1979). The kappa statistic provides a measure of “chance-corrected” agreement.
whereby a value of 1 indicates perfect agreement, 0 indicates agreement that would be expected through random chance, and -1 perfect disagreement. This approach was also used to assess the interrater reliability of using the composite measure of deviation for subgroups of head positions (lateral flexion, flexion/extension, or axial rotation deviations) and magnitude of deviation (5 degrees or 10 degrees).

RESULTS

Individually, assessor 1 was completely correct in 23 (43%) of 53 assessments, made 1 error in 25 (47%) assessments, and 2 errors in 5 (9%) assessments. Assessor 2 was completely correct in 21 (40%) assessments, made 1 error in 25 (47%) assessments, and 2 errors in 7 (13%) assessments. Assessor 3 was completely correct in 28 (53%) assessments, made 1 error in 15 (28%) assessments, and 2 errors in 10 (19%) assessments. Most frequently occurring were errors in identifying transverse plane (axial rotation) deviations (39 errors), followed by errors in detecting the magnitude of deviations (31 errors), and errors in identifying sagittal plane (flexion/extension) deviations (30 errors). Least frequently occurring were errors in detecting coronal plane (lateral flexion) deviations (18 errors). The median (interquartile range) of number of errors per plane of deviation, degrees of movement, and total number of planes of displacement are displayed in Figure 3, and the total number of errors for each individual position tested are displayed in Figure 4. Analyses of the effect of plane

![FIGURE 2 Model demonstrating positions of deviation with (a) one, (b) two, and (c) three planes of deviation.](image)

![FIGURE 3 Median (IQR) number of errors per position assessed for each plane of deviation, 5 and 10 degrees of movement, and the number of planes of deviation. A maximum of 12 and minimum of 0 errors were possible for any one position. Yes and no indicate positions that did or did not include that particular plane of deviation, respectively. *Median box overlies upperquartile bar.](image)
FIGURE 4 Number of errors (12 maximum) for each position.

Key:

F = Flexion
E = Extension
LL = Left lateral flexion
RL = Right lateral flexion
LR = Left rotation
RR = Right rotation
5 = 5 degrees
10 = 10 degrees
of deviation and magnitude of deviation on the number of errors observed for each assessment are demonstrated in Table 1.

The agreement between raters using the composite scale of head deviation was kappa=0.45. This dropped to kappa=0.30 when only assessment positions where the magnitude of deviation was 5 degrees were considered, but raised to kappa=0.51 when magnitude of deviation was 10 degrees. The agreement when considering assessments with a deviation in the transverse (axial rotation), sagittal (flexion/extension), and coronal (lateral flexion) planes was kappa=0.45, 0.35, and 0.28, respectively. This finding was at odds with the number of errors observed when a particular plane of deviation was involved (Table 1, transverse plane had the highest rate of error). It should be noted, however, that the composite scale only considers the number of planes of deviation (one, two, or three) and not which specific plane of deviation is involved.

### DISCUSSION

Visual observation is an elementary component of physiotherapy assessment for many patients. Used in a broad sense, it provides valuable information that can guide and direct further clinical investigations. With a more specific focus, it provides a low-cost and practical approach to the clinical assessment of alignment and range of motion. This study was the first to examine the accuracy of experienced physiotherapists’ visual observation skills for identification of multiplanar deviations of the head and neck on the trunk, and yielded a mixture of expected and unexpected results. A clear relationship was exhibited between the magnitude of deviations (larger deviations resulting in greater accuracy) and the number of planes of deviation (the more planes of deviation, the more errors) with the accuracy of the visual observation assessments. The relationship between accuracy and magnitude of deviation in the assessment of head and neck alignment is consistent with previous research using goniometers and visual observation in other body areas (Rose et al, 2002).

The three assessors were completely correct in only 40% to 53% of the positions of deviation examined. This was lower than expected, though may be a product of the relatively small magnitudes of deviations examined in this study. The composite scale of deviation used in this study demonstrated fair to moderate interrater reliability. Agreement between raters using this scale was most affected by the magnitude of deviation and head positions where there was a deviation in the coronal plane (lateral flexion). The limitations of physiotherapists’ visual observation skill and use of composite scales such as this must be recognized, though considered in the context of alternative approaches. Other tools for measurement of range of motion in the cervical spine, such as goniometer and inclinometer, have demonstrated a measurement error in the vicinity of 10 degrees or more (Jordan, 2000; Klaber Moffett, Hughes, and Griffiths, 1989; Nilsson, 1995). Even when spinal alignment is measured radiographically, there can be an error of 2.6 to 8.8 degrees and previous authors have argued an acceptable error magnitude of 5 degrees (Wills et al, 2007). Thus, the relatively low number of completely correct responses does not indicate that visual observation should be avoided, but rather highlights its limitations and enables comparison of tools to aid in the selection of the most appropriate measurement tool according to the context and requirements of the measurement. The complexity of assessing multiple planes of deviation simultaneously may have also contributed to this result.

The number of errors made was related to the planes of deviation involved in the positions assessed. Interestingly, deviations in the coronal plane (lateral flexion) were classified correctly most frequently; however, the number of total errors was twice as high for assessment of positions that included a deviation in this plane. This indicates that although deviations in this plane were relatively easy to identify, they made identifying deviations in other planes and the magnitude of deviations harder. Deviations in the transverse plane (axial rotation) were both hard to identify in themselves and resulted in a high number of

### TABLE 1 Effect of plane of deviation and magnitude of movement on number of errors observed for each assessment: Univariate Poisson (above) and multiple Poisson regression analysis (below)

<table>
<thead>
<tr>
<th>Predictor variable(s)</th>
<th>Incidence rate ratio</th>
<th>Robust 95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse (axial rotation) plane</td>
<td>2.19</td>
<td>1.25–3.84</td>
<td>0.006</td>
</tr>
<tr>
<td>Sagittal (flexion/extension) plane</td>
<td>1.06</td>
<td>0.70–1.59</td>
<td>0.78</td>
</tr>
<tr>
<td>Coronal (lateral flexion) plane</td>
<td>2.05</td>
<td>1.23–3.42</td>
<td>0.006</td>
</tr>
<tr>
<td>Magnitude (10 degrees) plane</td>
<td>0.65</td>
<td>0.43–0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>Number of planes of deviation</td>
<td>1.68</td>
<td>1.35–2.10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Multiple regression model*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse plane</td>
<td>2.17</td>
<td>1.35–3.49</td>
<td>0.001</td>
</tr>
<tr>
<td>Sagittal plane</td>
<td>1.08</td>
<td>0.83–1.42</td>
<td>0.59</td>
</tr>
<tr>
<td>Coronal plane</td>
<td>2.05</td>
<td>1.32–3.18</td>
<td>0.002</td>
</tr>
<tr>
<td>Magnitude (10 degrees)</td>
<td>0.65</td>
<td>0.46–0.91</td>
<td>0.013</td>
</tr>
</tbody>
</table>

*Number of planes dropped from multiple regression model due to collinearity.
total errors, whereas deviations in the sagittal plane (flexion/extension) had little effect on the total number of errors observed.

This study has been the first to examine the identification of deviations in multiple planes of movement simultaneously. The finding that presence of deviation in one plane can impact on the ability of physiotherapists to identify deviations in other planes is novel. Clinicians should now be cognizant of this confounding effect while performing their assessments and this should be incorporated into the training of visual observation skills of health practitioners. Though not investigated in the present study, the ability of the clinician to view the patient from multiple perspectives may aid accuracy in identifying multiplanar deviations; however, this may not always be possible in the clinical setting. In situations where assessment from a range of perspectives is impeded, for example the rehabilitation of a functionally dependent patient, therapists need to consider the implications of this and according to the degree of accuracy required, clinical practicality, and treatment goals, determine the appropriateness of using an alternative tool.

A diverse range of tools are available for the measurement of alignment and range of motion, each with a degree of measurement error, and some limited in their clinical practicality. If accurate detection of small (5-degree) deviations in head position is imperative for patient care, then approaches utilizing advanced technology are preferable. Technology-based approaches, however, may be costly to purchase, require training and technical skill, and be time consuming or inefficient to use in a busy clinical environment. In contrast, the universal goniometer is a relatively inexpensive instrument requiring only basic training to use, but demonstrates poor intertester reliability (Youdas, Carey, and Garrett, 1991) and is yet to be tested in conditions of multiplanar deviation of the head.

We argue that the use of visual observation for assessment of deviation in head position is justified for a majority of clinical situations, though clinicians should be wary of its limitations in regards to magnitude of deviation (decreasing accuracy with smaller magnitude of deviation) and confounding in assessment of individual planes with deviation in another.

This research was limited by the magnitude of deviations being contained to 5 and 10 degrees. Examination of larger degrees of motion would likely strengthen the trend that physiotherapists can more easily visually assess deviations of greater magnitude. It is arguable that the limitations of visual assessment for small deviations of 5 degrees are of clinical relevance; however, the investigators were interested in determining the accuracy of visual observation for subtle deviations.

Multiplanar deviations of the head may not contain deviations of equal magnitude away from the neutral in each plane of deviation, as was modeled in the present study. For the present investigation, however, attempt was made to limit the near-infinite permutations and combinations of deviations to a manageable amount that would be amenable to statistical analysis and interpretation. A further limitation was the assessment of the subject from in front only. Making the same assessments from different viewing perspectives, such as side on or from behind, may yield different results with respect to the relationship between the planes of deviation and errors.

This research has given rise to further potential areas of investigation. First, the accuracy of physiotherapists’ visual observation of movement in other joints or joint complexes capable of multiplanar movement should be established and contrasted to that observed in the present study. Second, whether equipping physiotherapists with the knowledge gleaned from this investigation (particularly in relation to the confounding introduced by deviations in one plane to the assessment of deviations in another) can improve the accuracy of visual observation of deviations of the head and neck complex. Third, the accuracy of visual observation when assessment from multiple perspectives is permitted should be contrasted to the present study. Finally, other aspects of visual observation of spinal posture not incorporated into the present study (e.g., translation deviations) should be investigated to inform clinicians and researchers of error and to optimize clinical approaches to the assessment of spinal posture.

**CONCLUSION**

Visual observation is an important component of clinical assessment of alignment and range of motion. Previous studies of the cervical spine have investigated measurement of uniplanar range of motion. This study is the first to investigate multiplanar deviations and has identified the limitations of visual observation for assessing multiplanar deviations that are 5 degrees from the neutral position of the cervical spine. These limitations, however, are similar to available alternative approaches to measurement of uniplanar range of motion, indicating that visual observation could still be a preferred option clinically. Further research investigating the accuracy of visual observation in the clinical assessment of multiplanar motion of the spine and other joints, from single and multiple perspectives, is warranted.
Declaration of Interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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