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Original article

High variability of the subjective visual vertical test of vertical perception, in some people with neck pain – Should this be a standard measure of cervical proprioception?

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ABSTRACT

Background: Subjective visual vertical (SVV) assesses visual dependence for spacial orientation, via vertical perception testing. Using the computerized rod-and-frame test (CRFT), SVV is thought to be an important measure of cervical proprioception and might be greater in those with whiplash associated disorder (WAD), but to date research findings are inconsistent.
Objective: The aim of this study was to investigate the most sensitive SVV error measurement to detect group differences between no neck pain control, idiopathic neck pain (INP) and WAD subjects.
Design: Cross sectional study.
Methods: Neck Disability Index (NDI), Dizziness Handicap Inventory short form (DHIsf) and the average constant error (CE), absolute error (AE), root mean square error (RMSE), and variable error (VE) of the SVV were obtained from 142 subjects (48 asymptomatic, 36 INP, 42 WAD).
Results: The INP group had significantly ($p < 0.03$) greater VE and RMSE when compared to both the control and WAD groups. There were no differences seen between the WAD and controls.
Conclusion: The results demonstrated that people with INP (not WAD), had an altered strategy for maintaining the perception of vertical by increasing variability of performance. This may be due to the complexity of the task. Further, the SVV performance was not related to reported pain or dizziness handicap. These findings are inconsistent with other measures of cervical proprioception in neck pain and more research is required before the SVV can be considered an important measure and utilized clinically.

1. Introduction

People with neck pain often complain of dizziness and demonstrate sensorimotor control deficits, including disturbances in head movement control (Revel et al., 1991; Treleaven et al., 2003), postural stability (Sjöström et al., 2003; Treleaven et al., 2005c; Field et al., 2008) and oculomotor control (Tjell et al., 2003; Treleaven and Jull, 2005a). Altered afferent cervical input or proprioception to the sensorimotor control system is thought to be responsible for these disturbances and the assessment and treatment of altered cervical proprioception and sensorimotor function is being recognized as an important component in management of neck pain (Treleaven, 2008; Kristjansson and Treleaven, 2009). A recent review of promising assessments of cervical proprioception for those with neck pain included cervical joint position and movement sense and the assessment of subjective visual vertical (SVV) using the computerized rod-and-frame test (CRFT) (Humphreys, 2008), however, to date, whilst the former tests are often used clinically, SVV is not, and research in this area has demonstrated inconsistent results (Bagust, 2005; Docherty et al., 2012).

SVV is an assessment of the magnitude of dependence on visual input for spacial orientation which requires input from visual, somatosensory and vestibular inputs (Lackner and DiZio, 2000). SVV using the CRFT examines the participant's error to adjust a rod vertically within a frame that is offset at several angles to provide some visual conflict. Studies have developed methods and criteria for the assessment of SVV in patients with neck pain, such as computer based assessment, use of video glasses, the degree of offset of the frame and rod, type of rod (i.e. rod or dot) and conditions and number of repetitions of the test (Bagust, 2005; Docherty et al., 2012; Takasaki et al., 2012b).

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When somatosensory inputs become abnormal (Rubin et al., 1995; Guerraz et al., 2001), the magnitude of dependence on visual input may be enhanced and SVV errors increase. Some studies demonstrated that SVV errors are larger in those with neck pain (Grod and Diakow, 2002; Docherty et al., 2012; Uthaikhup et al., 2012). Further, it is hypothesized that people with whiplash associated disorders (WAD) will have more impairment in the SVV than those with idiopathic neck pain (INP), as individuals with WAD, especially those complaining of dizziness, are associated with greater sensorimotor dysfunction compared to those with INP in other sensorimotor measures (Treleaven et al., 2003, 2005b; Field et al., 2008). However, this hypothesis has not been clearly accepted to date (Grod and Diakow, 2002; Docherty et al., 2012). It is possible that this could be due to the limited measurement methods of SVV error that have been considered to date.

Previous studies in the field of SVV have used absolute error (AE) and/or constant error (CE) only (Grod and Diakow, 2002; Docherty et al., 2012; Uthaikhup et al., 2012). However, these measures do not represent altered variability, thought to be a measure of an altered strategy to perform a task, which has been identified in people with pain when compared to pain free individuals (Falla, 2004; Falla et al., 2007; Woodhouse and Vasseljen, 2008). Variable error (VE) and root mean square error (RMSE) are often used as measures of variability in the field of physical assessments (Hill et al., 2009; Boucher et al., 2012). It is hypothesized that these measures of variability will be more sensitive to detect SVV differences between the groups than the other error measures. Therefore, the aim of this study was to investigate group difference in the SVV using AE, CE, VE and RMSE between individuals without neck pain (control group), those with persistent INP and those with WAD.

2. Methods

2.1. Subjects

Subjects aged 18–60 years were recruited from a whiplash clinic at the university, local physiotherapy practices and the local community. Inclusion criteria for people with neck pain was neck pain of at least three months duration and a Neck Disability Index (NDI) score of at least 10%, indicating disability due to neck pain (Vernon and Mior, 1991). All persistent WAD participants were classified as WAD II according to the Quebec task force (Spitzer et al., 1995). Inclusion criteria for non-neck pain control individuals were no history of head/neck/upper limb pain or trauma during the last three months. The exclusion criteria for both groups consisted of neck trauma associated with post-traumatic amnesia or concurrent head injury, cervical fracture/dislocation, known vestibular pathology and neurological/cardiovascular/respiratory conditions. Ethical clearance was obtained from XXXX and was adhered to throughout the study.

2.2. Measurements and procedure

2.2.1. Questionnaires

All subjects completed a general questionnaire concerning demographics and any dizziness using the Dizziness Handicap Inventory (short form) (DHIsf), which assessed perceived levels of handicap associated with any dizziness (Tesio et al., 1999).

People with neck pain also completed a general questionnaire detailing their history of onset of neck pain (WAD or INP) and the NDI (%).

2.2.2. Subjective visual vertical

The CRFT protocol used by Takasaki et al. (2012b) was used to measure SVV. The CRFT program was written in LabVIEW 6, National Instruments Corp., Austin, USA. A rod (tilted at either 20° anticlockwise or clockwise) consisting of two white dots representing each end of the rod, was set within a white square frame tilted at either 18° clockwise or anticlockwise from the vertical and these were displayed on a black background (Bagust, 2005 #2405; Isableu et al., 2008; Docherty et al., 2012). The rotation of the rod was controlled by dragging and turning a button, created on the lower right screen, using a computer mouse. The rod could be adjusted by a minimum of 0.01° (Fig. 1). There were four presentations in one session and the session was repeated five times as directed by previous research (Takasaki et al., 2012b). The order of the four presentations was randomized by the computer program.

The clockwise deviations from the true vertical were recorded as positive values and the anticlockwise deviations from the true vertical were recorded as negative values. In each frame condition, the deviations of the two pre-set dot conditions were averaged and a mean value was used (Isableu et al., 2008; Docherty et al., 2012; Takasaki et al., 2012b).

2.2.3. Error calculations

Four error calculations (Hill et al., 2009) were assessed: 1) mean AE, 2) mean CE, 3) mean VE and 4) mean RMSE. AE is the average magnitude of error, CE is the average direction of the error, VE is the overall variability of the error, while RMSE represents an overall measure of how successful the subject was in achieving the true vertical. The mathematical calculations used for each error are presented in Fig. 2.

2.2.4. Procedure

The subjects were seated in front of a computer screen. They were instructed to extend their legs and ensure only their heels were in contact with the ground in order to limit proprioceptive cues (Isableu et al., 2008). They were then instructed to adjust the rod to the true vertical by imagining a line between the two dots. One practice test session was conducted followed by feedback on performance by the researcher. The subjects then put on a pair of video eyeglasses (80″ 3D Virtual Video Glasses, Zetronix Corp., Allston, USA) so that the only visual input was the two white dots and the white frame. The video eyeglasses simulate an 80-inch wide image at 2 m distance (Fig. 1).

3. Statistics

Data of the error in SVV except CE was not of a normal distribution and thus non-parametric analysis was used. Preliminary analyses indicated no differences between the two frame conditions in each group and thus the measures of the two frame conditions were averaged to give four outcome measures for each subject.

To compare the three groups (Control, INP and WAD), a Kruskal–Wallis test was used to determine differences in SVV data as well as other measures in this study to understand group characteristics. As a post-hoc analysis, the two-tailed Wilcoxon signed-rank test with Bonferroni adjustments was used to compare the difference between each group in instances when Kruskal–Wallis test detected overall group differences. To preliminary explore a relationship between disability due to dizziness and SVV, scatter plots were examined.

SPSS Version 22 was used for statistical analyses. Level of significance was set at $p < 0.05$. Data is presented with mean and standard deviation (SD) unless specified.

4. Results

Fifty-one healthy individuals and ninety-two people with neck pain were included. Seventeen individuals were excluded (3