J Rehabil Med 2005; 37: 224–229

STANDING BALANCE IN PERSISTENT WHIPLASH: A COMPARISON BETWEEN SUBJECTS WITH AND WITHOUT DIZZINESS

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Objective: **Dizziness and unsteadiness, associated with altered balance, are frequent complaints in subjects suffering persistent whiplash associated disorders. Research has been inconclusive with respect to possible aetiology. This study assessed balance responses in subjects with whiplash associated disorders, taking into account several possible causes.**

Design: **A prospective, 3 group, observational design.**

Subjects: **100 subjects with persistent whiplash associated disorders, 50 complaining of dizziness, 50 not complaining of dizziness and 50 healthy controls.**

Methods: **The Clinical Test for Sensory Interaction in Balance was performed in both comfortable and tandem stance. The sway trace was analysed using wavelet analysis.**

Conclusion: **The results indicated that the energy of the sway signal for comfortable stance tests was significantly greater in the group with dizziness compared with the group without dizziness. In the group without dizziness the energy was greater than controls for all tests, but significantly different on selected tests. In selected tandem stance tests, subjects with dizziness were significantly less able to complete the test than subjects without dizziness and controls. These deficits could not be attributed to medications, compensation, anxiety or age and are likely to be due to disturbances to the postural control system possibly originating from abnormal cervical afferent input.**

Key words: balance, whiplash, postural control, proprioception, dizziness.

J Rehabil Med 2005; 37: 224–229

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Submitted February 4, 2004; accepted December 12, 2004

INTRODUCTION

Dizziness and/or unsteadiness and episodes of loss of balance are not infrequent complaints of persons with persistent whiplash associated disorders (WAD) (1). It is important to determine the likely aetiology of these balance problems in order to improve evaluation and rehabilitation. There are several factors to be considered in designing studies to have a clearer understanding of the aetiology of balance disturbances in whiplash, including consideration of possible origins, study cohorts and signal analysis.

In relation to origins of symptoms of dizziness and unsteadiness, some believe they could be attributed to side-effects of medications, to anxiety caused by either the ongoing problems of persistent WAD or fear of falling, to malingering or to symptom amplification due to the litigious nature of WAD (2, 3). Nevertheless, most of these factors have not been studied directly in WAD. Other researchers assert that trauma in a whiplash injury may damage any of the key systems for postural control, including the vestibular receptors, neck receptors or the central nervous system (4–6). Chronic pain is also considered to affect the central nervous systems' modulation of proprioceptive afferent information (7, 8). In the absence of a traumatic brain injury, symptoms following a whiplash injury are thought to arise from abnormal cervical afferent input either from damaged or functionally impaired neck joint and muscle receptors (4, 9). Cervical afferent information is important to the control of posture, spatial orientation and co-ordination of the eyes and head (10). There is some evidence to support the contention of a cervical cause of the symptoms of dizziness and balance disturbances. Subjects with WAD complaining of dizziness, compared with those without these symptoms, have been shown to have greater deficits in 2 other tests of postural control; cervical joint position error and smooth pursuit neck torsion. These deficits are considered primarily to reflect altered receptor input from cervical joint and muscle receptors (1, 9).

Concomitant features in study cohorts may also confound the interpretation of the postural control disturbance. Ageing is known to affect balance (11), but previous studies have not placed age limitations on subjects (6, 12–14). Cohort studies have included whiplash subjects with an associated mild head injury, which makes it difficult to determine the aetiology of the balance disturbances that were demonstrated (6).

Methods of analysis of sway have also varied between studies and large inter-individual variations in balance have been demonstrated (6, 12–14). The raw data from the computerized posturography (CDP) sway trace is a non-stationary signal and fractal in nature. Wavelet analysis has been adopted successfully in other medical research in an attempt to gather more accurate and specific data in such cases (15, 16). The relevance of the method of analysis was recently tested in our preliminary research (17). Wavelet analysis was shown to be more

 ISSN 1650-1977
DOI 10.1080/16501970510027989

appropriate and sensitive for detecting disturbances in balance in subjects with WAD compared with a more traditional analysis method, total sway distance, essentially because the technique allowed separation of the noise from the underlying systematic effect of sway (15, 17). While any form of smoothing the signal may be satisfactory, wavelet transforms are able to do this without the need for the extra step of reconstituting the signal (17, 18).

It is clear that further study of balance in patients with persistent WAD is necessary to assist in its recognition and the interpretation of the possible aetiology of balance disturbances. The major aim of this study was to determine whether postural stability responses differed between subjects with persistent WAD who reported dizziness and/or unsteadiness compared with subjects with persistent WAD not complaining of these symptoms and healthy controls. The design accounted for the factors of age, absence of mild head injury, anxiety level, medication intake and compensation status of the subject. Wavelet analysis was chosen as the method of analysis, as directed by our previous research.

MATERIAL AND METHODS

Subjects

Participants in this study included 100 subjects with persistent pain associated with WAD, at least 3 months post-injury. The subjects were recruited from consecutive eligible patients attending the Whiplash Research Unit in the Division of Physiotherapy at The University of Queensland and from volunteers sought through advertizing in the local newspaper and radio stations. Fifty subjects were sought for the dizziness group (WAD D). To be included, potential participants had to report episodes of dizziness or unsteadiness at least twice per week, which they related to their whiplash injury. The other 50 subjects reported no symptoms of dizziness or unsteadiness (WAD ND). Exclusion criteria included a reported period of unconsciousness, post-traumatic amnesia or concurrent head injury with the whiplash injury, known or suspected vestibular pathology such as benign paroxysmal positional vertigo, a history of dizziness prior to the whiplash injury, psychiatric conditions, neurological deficits and hip, knee or ankle pathology. Subjects were asked to refrain from taking any medication such as anti-inflammatory, antipsychotic and narcotic medication for 24 hours prior to testing as these might adversely affect postural sway (3). The subjects with WAD who were accepted into the study all had symptoms that were not abating and were categorized as WAD 11 according to the Quebec Task Force classification (19).

Control subjects included 50 healthy subjects with no history of whiplash, neck pain, headache or dizziness and were recruited from volunteers who responded to advertizing in a local newspaper and on the university campus. Any subject (WAD or control) over the age of 46 years was excluded to minimize the effects of ageing on balance (11).

Ethical clearance for this study was granted from the Medical Ethics Committee of The University of Queensland and all participants provided informed written consent.

Measurements

The subjects with WAD completed a series of questionnaires to provide demographic data and measures of pain, dizziness, anxiety and perceived disability to both pain and dizziness. A general questionnaire provided information related to the history of the whiplash injury, compensation status, current pain level using a visual analogue scale (VAS) and current regularly used medications. The Dizziness Handicap Inventory (DHI) (short form) (20) determined the perceived handicap associated with symptoms of dizziness/unsteadiness. This tool has been shown to be a reliable and valid measure of handicap associated with dizziness (20). The Neck Disability Index (NDI) (21), which incorporates pain and functional limitations, was used to determine the disability level associated with the neck pain. The State Trait Anxiety Inventory – Short Form (22) monitored both the "state" (how they felt at the time of the investigation) and the "trait" (how they generally felt) and provided a measure of anxiety associated with WAD.

Computerized posturography. Computerized posturography (CDP) was used as the measure of balance in this study. A computerized, stable force platform (40×60 centimetres) measured postural sway and changes in standing balance under altered visual and support conditions. The ground reaction forces were registered by strain gauges located in each corner of the plate to measure force changes over time in both the medial-lateral (ML) and anterior-posterior (AP) directions. The signals were recorded on a computer and the raw traces were produced both numerically and graphically.

The conditions for the Clinical Test for Sensory Interaction in Balance were performed with each subject standing in comfortable stance. The first 3 conditions were executed on a firm surface. Recordings of sway were made with the eyes open, eyes closed and under visual conflict, which was provided by wearing a lightweight paper dome on the head. To complete the 6 conditions, the 3 tasks were then repeated on a soft surface: eyes open soft, eyes closed soft and visual conflict soft. The soft surface was a piece of high-density (10-centimetre thick) foam rubber placed on the platform. The subjects' feet were repositioned exactly on each surface for every test using a paper traced foot position based on the "comfortable position" described by McIlroy and Maki (23). In tandem stance, the dominant foot was placed directly behind the non-dominant foot. Leg dominance was defined as the preferred leg to kick a ball (24, 25).

Procedure

The test order of tandem or comfortable stance was randomized while the order of the conditions for these tests were set. Subjects stood on the force platform with their feet in the required stance position. During each test condition they focussed on a spot on the wall at a distance of 1.5 metres and stood as steadily as possible with arms by their sides. The standardized procedure of the Clinical Test for Sensory Interaction in Balance over the 6 conditions was performed in comfortable stance. The 3 visual conditions were performed only on a firm surface in tandem stance, as our previous research had indicated that many normal and WAD subjects had difficulty with the tandem stance tests on a soft surface when vision was altered (17). One 30-second trial was performed for each condition as this time period has been shown to be sufficient to monitor sway and prevents exacerbation of pain from prolonged standing (26). An inability to stand without losing balance for a 30-second time period was recorded as failure to complete the particular test.

Data analysis

Failure rates for each test were compared between the WAD D, WAD ND and control subjects and the probability of difference of failure rates from controls was calculated for each test. For tests successfully completed, a Wavelet analysis using Daubechies filter 6 was performed for both AP and ML traces for each test condition. The wavelet transform converts the signal data into coefficients that capture the information about the signal at locations within the signal for the different frequencies. The first 4 levels of frequency of the wavelet analysis captured the systematic features of the signal and any higher frequency components were deemed noise. The variance of the wavelet coefficients is a measure of the amount of information coming from the different locations and frequencies and is termed "energy".

Our previous research demonstrated that although differences between individual coefficients could be found, there did not appear to be a consistent pattern of frequency, location and timing of the sway pattern for balance between tests. Rather, the differences between the sway trace of subjects with WAD and control subjects appeared to be the overall variance of the signal about zero sway (17). Thus in this study, we used the total of energies combined from the AP and ML traces at the first 4 frequencies to summarize the information contained in the trace.

Exploratory analyses for variables indicated that the standard deviation was proportional to the mean, which implies that a Gamma distribution be used to model the experiment error.

Table I. *Subject demographics for the whiplash groups (WAD D and WAD ND) and the control group*

	Control subjects	Whiplash subjects	
Subject demographics	Group C (n=50) Mean (SEM)	Group WAD ND (n=50) Mean (SEM)	Group WAD D (n=50) Mean (SEM)
Age (years)	29.9(1.4)*	35.8 (1.3)	35.6 (1.1)
Gender (% female)	56	76	76
Time since injury (years)	–	1.6 (0.14)	1.4 (0.11)
Pain at rest (VAS/10)	–	2.8 (0.29)	4.1 (0.32)*
Neck pain index (%)	–	34.4 (2.0)	46.4 (2.1)*
State anxiety (/80)	–	32.4 (1.4)	32.2 (1.4)
Trait anxiety (/80)	–	44.7 (1.5)	48.9 (2.0)
Involved in compensation (%)	–	68	74
Usually take medications (%)	–	52	70

SEM=standard error of the mean; WAD=whiplash associated disorders; ND=not dizziness; D=dizziness. * $p<0.05$ between WAD D and WAD ND subjects.

Both the "state" (how they felt at the time of the investigation) and the "trait" (how they generally felt) anxiety short scores of the State Trait Anxiety Inventory – Short Form (22) were prorated to the full score to allow comparison with other studies. The scores were calculated out of a possible score of 80, where a score of 20 indicates little anxiety and a score of 80 indicates maximum anxiety. The NDI was scored following the methodology of Vernon (21) to calculate the neck pain and disability index. The DHI (short form) (20) was scored out of a possible score of 13, where 13 indicates no dizziness handicap and 0 maximum handicap. An analysis of deviance using the normal distribution was used to investigate any differences between WAD groups for the neck pain index, VAS, age, duration since injury and anxiety scores.

Group differences due to signal energies were examined using a generalized linear model, MANOVA. To determine whether regular medication intake or compensation status could account for differences in balance responses, subjects were labelled categorically as either not, or usually taking medication, not seeking or seeking compensation. Medication use, compensation status, current and general anxiety levels, the NDI, VAS and age were included as separate factors in the MANOVA both for the WAD D group and the WAD ND group. Where these had a significant influence on within subjects balance measures, they were included into the final between-groups analysis as a co-variate.

A correlation analysis, Spearman's rho, was performed to determine any correlation between DHI, NDI, STAIT – trait and state, VAS and total energy of trace in comfortable stance. The statistical programs R and SPSS were used for all calculations.

RESULTS

There were no significant differences between the WAD groups for age, gender, anxiety scores (State and Trait), compensation status, medication status or duration of symptoms (Table I). There was a significant difference between the WAD D and WAD ND groups in the measures of pain on both the current pain level (VAS) and the NDI scores. For both measures, the group reporting dizziness (WAD D) scored higher than the group without dizziness (WAD ND) (Table I). The control group was significantly younger than the WAD groups and to ensure this did not influence the results, age was included as a factor in the between-group analysis.

The mean and standard errors for the energy for each test in comfortable stance for the WAD D, WAD ND and control groups are depicted in Fig. 1. Age, VAS and general Trait scores were included as factors in the analysis. The results indicated that for the 6 conditions of comfortable stance tests, the total energy of the sway was statistically greater in the WAD D group than in the WAD ND group. Energy levels on each comfortable stance test were also greater in the WAD ND group than in controls.

The number of subjects who were unable to complete the 30-second tandem stance test for the WAD, WAD ND and control groups and the probability of difference of failure rates between groups for each test are depicted in Table II. While all subjects (WAD ND and D and controls) could complete the 30-second tests in comfortable stance, a number of the subjects were unable to complete the tandem stance tests. WAD D and WAD ND subjects lost stability significantly more often in the tandem stance measures compared with controls, particularly in tests of altered vision. However, WAD ND did not lose stability as often as WAD D subjects.

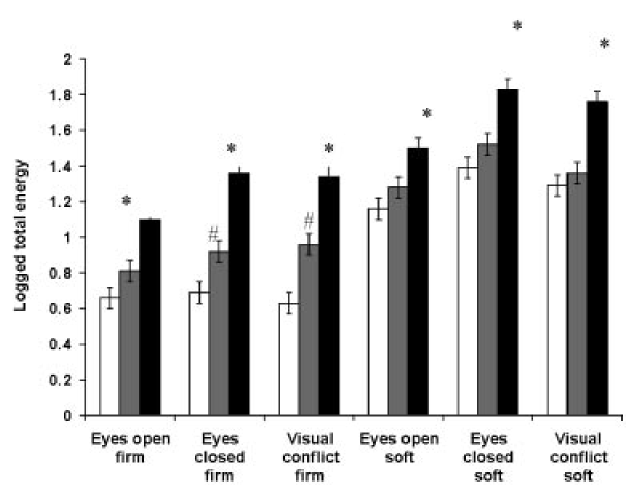

Fig. 1. Comparison of mean and standard error of total energy for each comfortable stance test between controls (□), WAD ND (▩) and WAD D (■). *$p<0.05$ between WAD D and WAD ND subjects. #$p<0.05$ between WAD ND and control subjects. WAD=whiplash associated disorders; ND=not dizziness; D=dizziness.

Table II. *Percentage of control and whiplash (WAD D vs WAD ND) subjects unable to complete tandem stance tests*

	Tandem stance tests		
Group	Eyes open firm	Eyes closed firm	Visual conflict firm
Control	0	15.78	10.53
WAD ND	18	50*	60*
WAD D	38*	72*	74*

* Statistical significance of group difference to controls in failure rates $p=0.05$.
WAD=whiplash associated disorders; ND=not dizziness; D=dizziness.

The between-subjects effects (F and *p* values) for both the WAD D group for medication use, compensation status, current and general anxiety levels, the NDI, VAS, duration of symptoms and age on each of the 6 comfortable stance tests is depicted in Table III. There was no within-subjects' effects for medication use, compensation status, age, duration of symptoms, reported levels of pain and disability (NDI) or current anxiety on any of the 6 balance test responses for both the WAD D and WAD ND groups. However, there were significant within-subjects' effects for the WAD D group, for both current pain (VAS) and the general level of anxiety (Trait score) with most of the 6 comfortable stance tests. For the WAD ND group there were no significant between-subjects' effects for either the measures of pain (VAS) or Trait anxiety scores (Table III).

The correlation coefficients (Spearman's rho) between total energies of the comfortable stance test conditions and the DHI, NDI, VAS, State and Trait scores are depicted in Table IV. Mild to moderate correlations were evident between VAS scores and total energy of sway. In the WAD D group, DHI scores ranged from 1 to 12 (mean 6.51) and demonstrated moderate and significant correlations with pain (VAS) and NDI, and weak correlations with balance tests on the foam surface.

Anxiety scores were similar for both WAD groups. Trait (general) anxiety scores ranged from 19.98 to 79.92 (mean 46.29), while state (current) anxiety scores ranged from 19.98 to 56.61 (mean 32.69). There were no significant correlations between energy of the trace and State anxiety scores and mild significant correlations between balance and general anxiety scores (Table IV).

DISCUSSION

The results of this study confirm that there are deficits in postural responses in those subjects with persistent WAD who do and do not complain of dizziness and or unsteadiness compared with healthy control subjects. Subjects complaining of dizziness (WAD D) had greater deficits in balance responses than those subjects not complaining of dizziness (WAD ND) and these were evident in the energy of the sway signal in all 6 comfortable stance tests, i.e. eyes open, eyes closed and visual conflict on both a firm and soft surface. Similar differences were present in ability to complete tests of tandem stance on a firm surface when vision was altered but more WAD ND subjects were able to complete the tandem stance eyes open test than were WAD D subjects. The balance disturbances were less in subjects without dizziness, but still greater than control subjects.

In contrast to other opinion (3), the results indicate that age (within the age range tested in this study), medication, anxiety at the time of testing and compensation were not the likely causes of these balance disturbances or the symptom of dizziness in subjects with WAD in this study. We limited the effects of ageing by excluding subjects older than 46 years and included age as a co-variate in the analysis between groups (11). As the subjects were relatively young in this study, ageing effects were not expected. Nevertheless it will be important to consider the combined effects of ageing and a whiplash injury in future studies of older cohorts. Likewise we minimized the effects of medication by requesting subjects to temporarily cease medication for at least 24 hours prior to testing. Even if this washout period was insufficient for some medications, there were no apparent differences in balance responses between subjects who regularly took medications and those who did not. There was also no difference between subjects with WAD with and without dizziness with respect to age, compensation status, and current and general anxiety levels.

Table III. *Between-subjects effects (F and* p *values) for subjects with whiplash associated disorders (WAD) with dizziness (WAD D) for age, compensation status, duration of symptoms, medication use, current and general anxiety levels, the Neck Disability Index (NDI), and visual analogue scale (VAS) on each of the 6 comfortable stance tests. (Degrees of freedom=1)*

Test	Eyes open firm F (*p*)	Eyes closed firm F (*p*)	Visual conflict firm F (*p*)	Eyes open soft F (*p*)	Eyes closed soft F (*p*)	Visual conflict soft F (*p*)
Age	0.09 (0.7)	1.14 (0.2)	0.12 (0.9)	0.24 (0.6)	1.8 (0.2)	0.49 (0.5)
Compensation	0.71 (0.4)	0.43 (0.5)	0.02 (0.8)	0.01 (0.9)	0.03 (0.9)	0.26 (0.6)
Duration	0.16 (0.6)	0.02 (0.9)	0.15 (0.7)	0.08 (0.8)	0.04 (0.8)	0.00 (1)
Medication	0.00 (1)	0.11 (0.8)	0.56 (0.5)	0.00 (0.9)	0.19 (0.7)	0.87 (0.4)
NDI	0.63 (0.4)	0.43 (0.5)	0.32 (0.6)	1.42 (0.2)	1.83 (0.2)	2.43 (0.1)
State	2.94 (0.1)	1.3 (0.3)	1.42 (0.2)	0.63 (0.4)	2.31 (0.1)	0.79 (0.4)
Trait	4.08 (0.05)*	2.22 (0.2)	5.13 (0.03)*	7.09 (0.01)*	7.33 (0.01)*	3.9 (0.05)*
VAS	10.44 (0.0)*	7.49 (0.01)*	5.52 (0.02)*	2.69 (0.1)	7.77 (0.0)*	8.82 (0.01)*

* Significant between-subjects effect.

Table IV. *Correlation co-efficients (Spearmans rho) between total energies of each of the comfortable stance test conditions and the reported levels of neck pain and disability, dizziness, and anxiety*

	DHI	NDI	State	Trait	VAS
Eyes open firm	NS	NS	NS	0.26*	0.39*
Eyes closed firm	NS	NS	NS	NS	0.38*
Visual conflict firm	NS	NS	NS	0.27*	0.33*
Eyes open soft	NS	NS	NS	0.32*	0.32*
Eyes closed soft	−0.41*	NS	NS	0.32*	0.36*
Visual conflict soft	−0.34*	0.28*	NS	0.30*	0.41*
DHI	1	−0.63*	NS	0.45*	−0.56*
NDI	−0.63*	1	NS	0.38*	0.53*
VAS	−0.56*	0.53*	0.38*	0.34*	1
State	NS	NS	1	0.57*	0.38*
Trait	0.45*	0.38*	0.57*	1	0.34*

* Significant at $p=0.01$; NS=not significant; DHI=Dizziness Handicap Inventory; NDI=Neck disability index; VAS=Neck pain intensity; State=anxiety level at time of testing; Trait=General anxiety level.

As expected, Trait and State anxiety scores for the WAD group were higher than normative values (27), but there were no differences in anxiety levels between those who did and did not complain of dizziness. Furthermore, anxiety level at the time of testing (State) did not appear to influence balance responses, which would be expected if anxiety was the predominant feature of the balance disturbances (28). General anxiety level was found to have some association with balance responses in the WAD D group, but this did not account for differences in responses between the WAD groups. These findings are not surprising as patients with balance system dysfunction often report anxiety as a prominent symptom (28). The neurochemical and neuropharmacolgical linkages as well as the numerous central interconnections between the balance system and the autonomic nervous system are thought to explain how anxiety may exert direct effects on balance functioning and vice versa (29). Our results support the view that balance responses were not due to anxiety at the time of testing and, while general anxiety is not the cause of the postural disturbance, it may influence some of the balance responses or vice versa (30). In our study, anxiety levels were similar between groups and general (Trait) anxiety was seen to influence balance responses only in the group with the greatest balance deficits (WAD D).

We contend that our data supports the view that balance disturbances in those with persistent WAD are most likely due to disturbance to the postural control system. The whiplash injury may damage any of the elements important for postural control. Direct central nervous system dysfunction was an unlikely cause as subjects were excluded if they reported an unconscious period or suffered a direct blow to the head associated with their motor vehicle crash (27, 31). However the influence of central nervous system changes due to chronic pain cannot be excluded (7, 8). Interestingly only current pain levels at the time of testing (VAS) and not the perceived level of pain and disability (NDI) was seen to influence balance responses in the WAD D group. Neither of these influenced the balance responses from the WAD ND group. Subjects were excluded if they reported diagnosed or suspected vestibular pathology. Nevertheless undiagnosed vestibular pathology could not be eliminated. Thus it is possible that the balance disturbances seen in this study could be due to disturbed afferent input from the cervical afferents, to chronic pain or to undiagnosed vestibular pathology. It has also been suggested that abnormal afferent input from the cervical spine could act as a trigger to altered peripheral vestibular function (32, 33).

We suggest that disturbance of afferent input from cervical receptors is the more likely primary cause. Disturbances in cervical afferent input have been demonstrated previously in subjects with WAD complaining of dizziness and or unsteadiness through disturbances in joint position error and in the smooth pursuit neck torsion test (1, 9). These studies showed that whiplash subjects with dizziness had greater deficits in cervical mechanoreceptor dysfunction than subjects with whiplash not complaining of these symptoms, suggesting that dizziness is caused by a mismatch of abnormal cervical and normal vestibular information. This study also confirms that the balance deficits are greater in a WAD group complaining of dizziness when compared with subjects with WAD not complaining of these symptoms. The fact that some balance deficits exist in those not complaining of these symptoms does not favour a vestibular cause but also supports the notion that the balance deficits are likely to be from a cervical afferent origin.

The results of this study have demonstrated deficits in balance in subjects with WAD that are likely to be due to postural control disturbances and not to medication, anxiety and compensation status; however, further research will be required to determine more precisely the nature of the disturbance to the postural control mechanisms following a whiplash injury. The results also support the use of wavelet analysis in assessment of balance in subjects with WAD as this method of analysis was able to detect balance disturbances and to determine differences between those subjects with WAD who did and did not complain of dizziness and or unsteadiness. Nevertheless, future studies to investigate the sensitivity and specificity of this method against other groups with balance disorders such as a vestibular disorder or stroke will be important to validate further the use of wavelet analysis in the measurement of sway. Comparison between such subject groups and those with WAD may also provide valuable information to assist in the interpretation of the nature and causes of balance disturbances in WAD. While we have adequately used a summary of the information from the wavelet trace in this study, the use of wavelet transform rather than other signal analysis methods, also allows scope for the use of more specific information about the signal at locations within the signal for the different frequencies. This could be particularly useful when comparing between groups such as vestibular or whiplash subjects, or when evaluating an individual's response to certain treatment.

In conclusion, this study has determined that balance is disturbed in persons with persistent WAD and that these findings cannot be attributed to age, medication, compensation status or anxiety at the time of testing. Subjects who complained of dizziness and unsteadiness were found to have greater balance deficits than those not complaining of these symptoms. However, those not complaining of dizziness still had altered responses compared with control subjects in selected tests. The balance disturbances are likely to be due to disturbed afferent input from the cervical receptors or the influence of chronic cervical pain on the central nervous system. Further research is needed to clarify the role that the vestibular system may play in these balance disturbances, the precise nature of these disturbances as well as the value of wavelet analysis in detection and assessment of balance disturbances in WAD. Current clinical assessments and management of patients with WAD rarely include specific tests of balance. Based on the findings from this study, we advocate that assessment of balance performance should be performed routinely in order to select those subjects with WAD who may benefit from intervention to improve balance and postural control.

ACKNOWLEDGEMENTS

This research was supported by grants from the Physiotherapy Research Foundation and The Centre of National Research on Disability and Rehabilitation Medicine (CONROD). We thank Dr Robert Murison for statistical assistance with the wavelet analysis.

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