ORIGINAL ARTICLE

Prevalence of Aphysiologic Performance on Dynamic Posturography in Work-related Patients

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Posturography; Postural balance; Dizziness; Imbalance; Work; Occupational; Malingering; Vestibular

Abstract

Introduction and objectives: Medical-legal implications of dizziness and imbalance in work-related patients are important. In these cases, computerized dynamic posturography (CDP) adds information to standard vestibular tests and aphysiologic patterns have been described. The objective is to assess the prevalence of aphysiologic performance on CDP in work-related patients complaining of dizziness/imbalance.

Materials and methods: Retrospective review of patients referred by the workers’ compensation board for assessment of dizziness, imbalance or both. Standard vestibular assessment including CDP was carried out in all patients. The sensory organization test (SOT) summaries were scored as normal, aphysiologic or vestibular using the scoring method published by Cevette et al. in 1995.

Results: Aphysiologic performance in SOT, evaluated with the Cevette formula, was found in 31 out of 100 cases. Low composite score results and aphysiologic SOT results had a statistically significant association (P=.01). Videonystagmography (VNG) was altered in 14 out of 31 cases with aphysiologic SOT.

Conclusion: The 31% prevalence of aphysiologic results on CDP among work-related patients complaining of dizziness/imbalance is relatively high in comparison with the 25% published by Longridge and Mallinson in 2005. However, aphysiologic performance should not necessarily be related to malingering or exaggeration and altered vestibular tests are found in some of these cases.

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Prevalencia de test afisiológicos de posturografia dinámica en pacientes laborales

Resumen

Introducción y objetivos: El vértigo y la inestabilidad tienen una importante implicación médico-legal en el paciente laboral. La posturografia dinámica computarizada (PDC) aporta información adicional a las pruebas vestibulares estándar, pero además se han descrito patrones de control postural compatibles con escasa colaboración o falta de sinceridad al esfuerzo, denominados afisiológicos. El objetivo de este trabajo es determinar la prevalencia de test afisiológicos en estudios de PDC sobre pacientes laborales con vértigo y/o inestabilidad.

Material y métodos: Estudio retrospectivo de pacientes remitidos por mutuas laborales para estudio de vértigo y/o inestabilidad. Se realizó un estudio vestibular estándar y PDC. Los resultados de la prueba de organización sensorial (sensory organization test [SOT]) se valoraron como normales, vestibulares o afisiológicos usando el método de cálculo publicado por Cevette et al. en 1995.

Resultados: El patrón afisiológico en el SOT, definido por los índices de Cevette, se observó en el 31% de los casos estudiados. Se ha encontrado una relación estadísticamente significativa (p = 0,01) entre los valores bajos de la puntuación compuesta (composite score) y el resultado afisiológico. La videonistagmografía (VNG) presentaba alteraciones en 14 de los 31 casos con SOT afisiológico.

Conclusiones: La prevalencia de casi un tercio de los resultados de PDC afisiológicos entre pacientes laborales con vértigo y/o inestabilidad en nuestro medio, es relativamente elevada en comparación con el 25% publicado por Longridge y Mallinson en 2005. El patrón afisiológico no necesariamente significa simulación o exageración, siendo frecuente la presencia concomitante de signos videonistagmográficos de vestibulopatía en estos casos.

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Introduction

Vertigo and instability cause a high level of disability and have significant economic and social implications. Therefore, they require a thorough assessment in patients referred by labour mutual insurance companies (working accidents and occupational diseases). These patients, as litigants, are entitled to financial compensation or secondary benefits associated with their condition, so, in theory, they could be tempted to exaggerate or simulate their symptoms. In these cases, the existence of objective and quantitative assessment systems can legitimise symptoms and facilitate the elaboration of medical reports on insurance claims.

Computerised dynamic posturography (CDP) is a test which assesses postural control whilst standing. It is reproducible, fast (10 min) and generally very well tolerated. In addition to videonystagmography (VNG), which is considered as the standard vestibular test, it provides information on the vestibulospinal pathway. Moreover, CDP has described patterns of what we might call ‘dubious collaboration’ or insincere effort, also known as aphysiological. This is interesting in the field of occupational vertigo, since a priori it would be the most likely scenario for such patterns. The aphysiological pattern was described by Hamid in 1990 and popularised by Cevette et al. in 1995. The latter proposed a series of formulas used to classify CDP as normal, vestibular or aphysiological.

The aim of this study is to determine, within our environment, the prevalence of normal, vestibular and aphysiological tests in CDP studies performed exclusively among labour-related patients, as well as their relationship to other vestibular function tests.

Materials and Methods

This was a retrospective study of 100 consecutive patients from labour mutual insurance companies and on sick leave (temporary disability), referred to a Vertigo and Balance Unit for a vertigo and/or instability study, between 2003 and 2011.

All patients reported vertigo, instability or both. All subjects underwent the following tests in this order: anamnesis, audiometric study, CDP and VNG.

CDP

We used a Smart Balance Master version 7.0.7 device from NeuroCom System (NeuroCom International Inc., Clackamas, U.S.A.). CDP assesses displacements of the body pressure centre to determine the degree of stability: angular difference between the maximum anteroposterior oscillation of a patient and the maximum limits of standard anteroposterior stability (\(12.5^\circ - (\text{max}-\text{min})/12.5^\circ \times 100\)). It is based on the assumption that the theoretical maximum anteroposterior displacement of an individual without falling is equal to \(12.5^\circ\). Thus, 0% would represent a fall and 100%, would mean minimal or no oscillation. In total, six conditions were studied (Fig. 1) and three tests were conducted for each condition. Studies of the sensory organisation test (SOT) of the CDP conducted were considered as normal, vestibular or aphysiological using the calculation method published by Cevette et al. in 1995. Calculation of the formulas (Table 1 and Fig. 2) was performed using an Excel Office, Microsoft.
Figure 1  The six conditions of computerised dynamic posturography.

Table 1  Formulas by Cevette et al. 

\[
\begin{align*}
Aphysiological &= -158.20+1.94 \times (\text{condition 1})+1.09 \times (\text{condition 2})+1.37 \times (\text{condition 4})-0.15 \times (\text{condition 6}) \\
Normal &= -238.14+2.24 \times (\text{condition 1})+1.45 \times (\text{condition 2})+1.70 \times (\text{condition 4})-0.13 \times (\text{condition 6}) \\
Vestibular &= -251.21+2.31 \times (\text{condition 1})+1.54 \times (\text{condition 2})+1.89 \times (\text{condition 4})-0.58 \times (\text{condition 6})
\end{align*}
\]

<table>
<thead>
<tr>
<th>Conditions</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>81</td>
<td>72</td>
<td>67</td>
<td>55</td>
<td>38</td>
<td>57</td>
<td>-58</td>
</tr>
<tr>
<td>Test 2</td>
<td>82</td>
<td>64</td>
<td>67</td>
<td>54</td>
<td>39</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Test 3</td>
<td>80</td>
<td>80</td>
<td>54</td>
<td>52</td>
<td>59</td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2  Numerical values of the sensory organisation test in an aphysiological case.

Corp. spreadsheet, developed by our group for this specific purpose.

VNG

We used a VO425 system, software 7.02 (Interacoustics) to conduct the spontaneous nystagmus study, as well as eye movement tests (saccades, tracking and optokinetic), positioning and positional nystagmus (Dix-Hallpike) and bithermal caloric testing (30–44°C). The results of VNG tests were considered as normal or altered. The criteria for considering a VNG curve as pathological were the presence of spontaneous and positional nystagmus or its appearance during the Dix-Hallpike test, alterations in extrinsic ocular motility (saccades, tracking, optokinetic nystagmus), canalicular paresis and directional preponderance. Heat anomaly was defined as a difference between both ears greater than 25% of the value in canalicular paresis. Directional preponderance was defined as any directional difference exceeding 28%. So as to order the most common findings in a practical manner, pathological VNG (altered) findings were divided into four subgroups: vestibular, specifying if there was benign paroxysmal positional vertigo (BPPV); central; mixed; cervical. Spontaneous nystagmus with peripheral characteristics, canalicular paresis and directional preponderance were considered vestibular and BPPV in the presence of complete classical response when performing the Dix-Hallpike manoeuvre. Spontaneous or positional nystagmus with central characteristics and qualitative alterations of the oculomotor system were classified within the central group. The typical findings of peripheral and central vestibular involvement were considered mixed. The presence of spontaneous or positional nystagmus without locator value, discarding BPPV, with normal caloric response was considered as cervical VNG. Statistical analysis was performed using the SPSS 15.0 program. The chi-square test was used for ordinal variables. Numerical data were assessed with the Student’s t-test if normally distributed and with the Mann–Whitney U-test if otherwise. The quantitative variables analysed were age, time of evolution and the value of the composite store; the qualitative variables analysed were gender, triggering cause and the results of the CDP, VNG and audiometry tests.

Results

Of the 100 patients studied from 7 labour mutual insurance companies, 59 were male (59%) and 41 were female (41%). Their mean age was 44.58 years (SD: 11.6) with a range between 19 and 64 years. The mean evolution time of symptoms was 9.08 m (SD: 13) with a range from 1 to 72 m. Symptoms were triggered in 47 cases by cervical whiplash injury (CW) (47%), in 22 by traumatic brain injury (TBI) (22%) and in 31 cases there was no history of CW or TBI (31%).

Audiometry was normal in 62 patients (62%), whereas 38 cases presented some degree of hearing loss (38%).

The CDP and VNG results and their combinations are summarised in Tables 2 and 3. Alterations found in the VNG were canalicular paresis in 21 cases (21%), eye movement...
alterations in 12 cases (12%) and spontaneous nystagmus in 10 cases (10%). Positional nystagmus was found in seven cases (7%), positioning nystagmus in five cases (5%) and directional preponderance in six cases (6%). There was no association between an aphysiological result in the CDP and normality in the VNG (P=.05). The result of vestibular CDP was related to altered VNG (P=.02) and the result of normal CDP to normal VNG (P=.02). Aphysiological results were not related to gender, age or duration of symptoms. The mean composite score was 38 for the aphysiological CDP (SD: 15.3), 50.6 for the vestibular CDP (SD: 11.18) and 73.8 for the normal CDP (SD: 7.2). There was a statistically significant correlation (P<.01) between the lowest composite scores and the aphysiological result.

Results for the working CW subgroup (n=47): CDP was aphysiological in 27.6%, vestibular in 12.7% and normal in 59.5%. The VNG was normal in 57.5% and altered in 42.5% (vestibular: 19.1%, central: 12.7%, and cervical: 10.6%).

Results for the working TBI subgroup (n=22): CDP was aphysiological in 50%, vestibular in 18.1% and normal in 31.8%. The VNG was normal in 50% and altered in 50% (vestibular: 31.8%; mixed 9.0% and central: 9.0%). We found no significant correlation (P>.05) between CDP results (aphysiological, normal and vestibular) and history (CW, TBI, absence of CW and TBI). The frequency of altered VNG was greater among cases of TBI, but there was no statistically significant correlation (P>.05) between the VNG result (normal/ altered) and a history of TBI.

### Discussion

Vertigo and instability are often highly disabling, so their working and social impact can be significant. A recent study conducted among 400 vertigo patients in two European cities found that 27% changed their jobs and 21% left them as a result of their condition. Over 50% felt that their work efficiency had decreased considerably and 57% perceived alterations in their social life. Moreover, as litigants, labour-related patients would secondarily benefit from their condition, so in theory they could attempt to exaggerate or simulate symptoms of vertigo and/or instability. In these cases and for the reasons described, it is especially important to have objective and quantitative assessment systems, in order to legitimise patient symptoms and facilitate the elaboration of medical and legal reports. CDP has described patterns consistent with scarce collaboration or aphysiological. An aphysiological posturographic pattern basically means that better relative results are obtained in difficult subtests and there is variability between tests (Fig. 3). Cevette et al. evaluated the posturographic results from a group of individuals who were asked to simulate instability, a group of normal controls and a group of patients with vestibular disease. Using a statistical model, they proposed some formulas (Table 1) to classify the SOT result of a CDP as normal, vestibular and aphysiological. These formulas enabled them to correctly classify 95.5% of patients. Other authors added new considerations

### Table 2

<table>
<thead>
<tr>
<th>Results of CDP. Cevette criteria</th>
<th>VNG Result. Type of Alteration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphysiological</td>
<td>Normal</td>
</tr>
<tr>
<td>No., %</td>
<td></td>
</tr>
<tr>
<td>Vestibular No., %</td>
<td></td>
</tr>
<tr>
<td>Normal No., %</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

BPPV: benign paroxysmal positional vertigo; CDP: computerised dynamic posturography; cervical VNG: considered in the presence of spontaneous or positional nystagmus with no localiser value, without BPPV and with normal caloric response; mixed VNG: typical findings of peripheral and central vestibular involvement; VNG: videonystagmography.

### Table 3

<table>
<thead>
<tr>
<th>Results of Dynamic Posturography According to the Criteria of Cevette et al.</th>
<th>Normal/Altered VNG Result</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aphysiological</td>
<td>Vestibular</td>
</tr>
<tr>
<td>Normal count, CDP %</td>
<td>17 (54.8%)</td>
<td>5 (26.3%)</td>
</tr>
<tr>
<td>Altered count, CDP %</td>
<td>14 (45.2%)</td>
<td>14 (73.7%)</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>19</td>
</tr>
</tbody>
</table>

Applved statistical Chi-square test; P=.029.

CDP: computerised dynamic posturography; VNG: videonystagmography.
to the aphysiological pattern. Goebel\textsuperscript{12} reported the usefulness of the motor control test. Mallinson and Longridge\textsuperscript{13} proposed nine criteria to define a test as aphysiological: better response in conditions 1 and 2 of the SOT when registering the postural control of patients without giving them prior notice; conditions 1 and 2 clearly below normality; conditions 5 and 6 relatively better than 1 and 2; circular oscillation without falling; high variability between trials; repeated oscillation patterns suspiciously consistent in SOT; exaggerated responses in the motor control test; inconsistent test scores in the motor control test; observer impression (clinical judgement). According to these authors, less than three criteria would mean that the CDP was not aphysiological; the presence of three or four criteria would be suspicious; five or more criteria would indicate an aphysiological test. Rey, Rama and Pérez\textsuperscript{4} noted that simulated patients presented clinical-exploratory disparity, whereas randomisation or repeated tests yielded different, non-repeatable results. While the scoring system of Cevette et al. presents some limitations,\textsuperscript{14} its main advantage is that it proposes a numerical value that is easy to understand and avoids any observer subjectivity. Thus, we have employed this method in the present study. King et al.\textsuperscript{1} reported 88.8% true positives using the formulas and Morgan et al.\textsuperscript{15} highlighted their ability to detect informed simulators, that is, healthy volunteers who were asked to feign instability, having been explained how to attempt to ‘cheat’ the system. To the best of our knowledge, to date there are no publications reporting the results of applying the formulas of Cevette et al.\textsuperscript{4} to a series of labour-related patients with vertigo or instability in our country. Knowing the prevalence of aphysiological results among these cases could contribute to a better evaluation thereof.

In our series, nearly one third (31%) of the SOT results from labour-related patients, scored by the system of Cevette et al.\textsuperscript{4} were aphysiological. Using their scoring system,\textsuperscript{13} Longridge and Mallinson\textsuperscript{14} considered one quarter of labour-related patients aphysiological. Although our percentage is high, we must take into account that VNG alterations were frequently observed (45.1%) in this group of patients (Table 3). This fact suggests that not all aphysiological results corresponded to simulating patients, but instead some of them could suffer real postural control deficits. We must consider that an aphysiological test result is not necessarily synonymous of simulation or exaggeration. Such results are sometimes associated to patients suffering a condition and presenting anxiety. Anxiety and other psychiatric disorders can cause aphysiological results\textsuperscript{1} which would justify the high percentage of aphysiological tests obtained in this work. On the other hand, we do not know what the prevalence of aphysiological results would be among non-labour mutual insurance patients, so these results should not be considered absolute. Gianoli et al.\textsuperscript{1} reported a 76% prevalence of aphysiological patterns within a trial group of litigating patients who were either labour-related or awaiting classification of disability degree (through normal audiovestibular assessment in 50% of cases), compared to 8% when there was no possibility of secondary gain. In our series, comprised exclusively of labour-related patients, we found no association (P > .05) between aphysiological CDP results and normal VNG. Neither did we find an association with the age of the patients, as described by Gianoli et al.\textsuperscript{1} Furthermore, we observed that low values in the composite balance score should make us suspect aphysiological results, even before calculating the formulas, especially in patients capable of walking without aids (disparity between symptoms and exploration). Previous authors\textsuperscript{2} have described lower, overall balance values in patients with vestibular pattern compared with patients with normal pattern, defending the usefulness of the score by Cevette et al.\textsuperscript{4} In our study, aphysiological tests showed a lower composite score than vestibular tests (P = .01). Clearly, an aphysiological result would not be the most desirable in a CDP, since it would not provide conclusive information. For this reason, in order to try to minimise the number of aphysiological tests, we suggest explaining to patients before starting the CDP, that it is a very sensitive system capable of detecting any small balance deficit they may suffer, and that exaggerated results will provide no useful information and will not help to legitimise conditions, so they are recommended to simply maintain balance in a relaxed manner.

Half (50%) of the patients in this study presented normal results in the SOT. Such a high percentage of normal CDP could be due to a bias in the origin of cases. Patients had a long time of evolution (9.08 months on average) and may have been referred to our unit for evaluation, suspecting no condition. Up to 62% of these individuals showed no VNG alterations (the association between normal CDP and normal VNG was significant, P < .05), so we could conclude that they showed no vestibular or postural control condition at the time. A total of 19% CDP in the series were vestibular, although CDP does not specifically assess the vestibular system. In 14 of the 19 patients (73.6%) with vestibular CDP, VNG was abnormal (Table 3) and a statistically significant association was found between the two results (P < .02). Although most pathological VNG were vestibular (n = 27; three BPPV), we must highlight the number of VNG with central (n = 13) and cervical (n = 5) alterations (Table 2). An explanation for this fact could be found in the history of vertigo and instability of our patients: 22 TBI and 47 CW. At this point it is worth clarifying that the definition of cervical alteration in the VNG test is necessarily controversial, since there are no specific findings.\textsuperscript{10} However, we must take into account that nearly half of our patients (47), had a history of cervical whiplash and this was the main cause of
vertigo/instability in our series. In some of these cases, we found VNG alterations which did not fit into more academic classifications. The mechanisms by which CW causes vertigo and/or instability have not been fully established. However, 42.5% (20 of 47) of these cases presented VNG alterations and 45% (9 of 20) of these alterations were peripheral, confirming that a sudden acceleration-deceleration could damage the vestibular system.\(^{16}\) Within the TBI subgroup, we observed that 50% of CDP (n=11) showed aphysiological results, without displaying statistical significance (P>.05). The frequency of altered VNG results was also higher among TBI cases. Nevertheless, there is no statistically significant relationship between them.

The rotating test could help to establish the degree of compensation of the vestibulo-ocular reflex, especially in cases with altered VNG and normal or aphysiological CDP. CDP is also useful to assess the degree of compensation in postural control/vestibulo-spinal reflex and, therefore, to monitor the evolution of patients with alterations. We cannot conclusively rule out the presence of impaired postural control in cases with aphysiological CDP, even with unaltered VNG, as referred by Norre et al.\(^{17}\) Discordance between the VNG and CDP results. CDP could be useful for monitoring these cases, and the study could be subsequently repeated if there was suspicion of simulation, as proposed by Rey et al.\(^{3}\) Moreover, it has been suggested that CDP could be more sensitive than VNG to detect vestibular system anomalies.\(^{18}\) In our study, five patients with normal VNG presented a vestibular, altered CDP (Table 3). Amin et al.\(^{19}\) considered that CDP provides additional information to VNG. Furthermore, CDP may enable physicians to establish a prognosis and a vestibular rehabilitation plan.\(^{18}\)

The study of vertigo and instability, especially when related to medical and legal reporting, must take into consideration the presence of objective signs,\(^{20}\) as in cases of labour-related patients in a state of temporary disability and patients awaiting recognition of their degree of disability. In the latter case, Royal Decree 1971/1999 on the procedures for recognition, reporting and grading of disability\(^ {21}\) establishes the criteria to qualify for a percentage of disability attributable to balance alterations. It specifies that there must be compatible clinical symptoms in addition to objective signs of vestibular dysfunction. It is likely that tests such as evaluation of dynamic visual acuity and vestibular evoked myogenic potentials, can give us additional information in these cases. However, so far, only CDP can be helpful when we suspect simulation or exaggeration by patients attempting to obtain a secondary benefit.

**Conclusion**

The prevalence of almost one third of aphysiological CDP results in labour-related patients with vertigo and/or instability in our environment is relatively high compared with 25% reported by Longridge and Mallinson in 2005. This does not necessarily mean that these patients were simulators or exaggerators and the presence of concomitant alterations in videonystagmography is frequent. The results of normal or vestibular CDP were statistically related to normal and impaired VNG, respectively.

Although low values in the overall score of the CDP (composite score) should arouse suspicion of aphysiological results, the standardised formulas of Cevette et al. provide a numerical value that is easy to interpret. Thus, they can offer useful objective information in the study of labour-related vertigo, especially for the elaboration of medical and legal reports.

**Conflict of Interests**

The authors have no conflicts of interest to declare.

**References**