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Objectification of psychogenic postural instability by trunk sway analysis

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ABSTRACT

Introduction: The attribution of balance or gait disorders to psychogenic origin can be exceedingly challenging, as clinical tests involving distraction maneuvers are prone to subjective bias. We tested the value of biomechanical balance analysis to identify psychogenic balance and gait (PBG) disorders.
Methods: We quantified and compared the effects of distraction maneuvers on balance based on four stance conditions (eyes open, EO; eyes closed, EC; EO on foam, EOF; and EC on foam; ECF) in subjects with suspected PBG ($n = 12$), subjects with balance and gait disorder due to multiple sclerosis (MS; $n = 12$) and healthy controls ($n = 12$). We measured trunk inclination in transverse plane $(°)^2$ and the corresponding body angular velocity (°/s). Distractibility of postural stability was analysed using ANOVA with repeated measures.
Results: In evident contrast to the MS group and healthy controls, the PBG group showed increased values of $(°)^2$ and (°/s) and significant distractibility in all four stance conditions.
Conclusions: Biomechanical balance analysis can help clinicians to get objective, quantified results of distraction maneuvers and confirm a positive diagnosis of PBG disorders. Large prospective studies are needed to confirm these results.

1. Introduction

Psychogenic gait is common in patients with unexplained neurological symptoms. Up to 60% of neurological patients have no detectable organic disorder that can explain their walking disturbance with postural instability [1,2]. Various terms have been used to describe this situation, such as psychogenic disorder or functional symptoms. The diagnosis of psychogenic movement disorders (PMDs) may be challenging, given the lack of accurate and reliable tests [3]. Clinicians may arrive at a correct diagnosis earlier on if distinctive positive signs are identified and acknowledged [3–5]. In clinical practice, diagnosis relies mainly on the observation of bizarre motor behavior, discrepancy between obvious dysfunction and normal test results, and evidence of psychiatric abnormalities [6]. It should be noted, that bizarre motor behavior can be a feature of organic movement disorders (e.g. geste antagoniste in cervical dystonia) and psychiatric abnormalities are common in all forms of neurological disease [7].

Some authors advocate the use of video analysis to support the clinical diagnosis of PMD [6,8]. Besides continuously optimized clinical criteria [9–12], neurophysiological measurements have become increasingly important to diagnose PMDs [13–21]. Therefore, several studies look at the use of posturography in psychogenic and feigned balance problems [22–24]. In general, physiological and biomechanical studies on PMDs are nominally present in the literature [25].

This study aimed to objectify a distractibility of psychogenic postural instability using a biomechanical analysis approach and comparing the equilibrium data of the psychogenic balance and gait (PBG) group with data of patients with multiple sclerosis (MS) and healthy controls (C).

2. Methods

Twelve patients with clinically suspected PBG (mean age 59.9 years (±18.4), six males) with normal electrophysiological and radiological tests but somatically unexplained postural instability in the Romberg test underwent video recorded gait and pull tests (Table 1) and a subsequent biomechanical equilibrium analysis. As control groups we recruited twelve MS patients with predominant spastic ataxic gait disorder (mean age 48.1 years (±11.3), eight males) with a mean Expanded Disability Status Scale score of 3.8 (±0.9) and twelve healthy controls (mean age 59.7 years (±18.4), six males).

We used the mobile equilibrium analysis system SwayStar™ as biomechanical measurement system [26,27]. In accordance to the operating manual the measurement device was applied to the lower back with a belt. Two accelerometers measured the angular deviation and angular acceleration of the upper body in the anterior/posterior (pitch) and medial/lateral (roll) direction (level of accuracy of <0.01 °/s). The trunk movements of the participants were recorded and transferred to a PC via a Bluetooth® wireless link connection (Fig. 1a).

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Table 1
Characteristic features of stance and gait in the 12 patients of the PBG group.

	n
Decelerated gait	8
Slowness of gait	6
Swaying gait	7
Walking with crossing feets (scissor gait)	2
Unstable line walk	3
"Walking on ice" gait pattern	2
Bizarre und unstable pull-test	9
Fall towards the examiner during walk	3
Improvement of gait with mild support	4
Limping gait	1

All subjects completed four double stance tasks "as stable as possible" over 20 s in the following order: standing with eyes open on a normal surface (EO), standing with eyes closed on a normal surface (EC), standing with eyes open on a foam support surface (EOF) and standing with eyes closed on a foam support surface (ECF). Subsequently, repeated measurements of the four stance conditions were carried out with continuous distraction maneuvers over 20 s. For this, the subjects were required to recognize numbers written on their backs (distraction maneuver based on Lempert et al. [6]). The numbers (range 0–100) were randomly selected and executed by the examiner with light finger pressure and slow movement speed. In total, there were eight trunk sway measurements (four measurements without distraction, four measurements with distraction; Fig. 1b).

PBG and MS subjects were recruited from inpatients without alteration of ongoing therapies (medication, physiotherapy). All participants gave their written consent for retrospective data analysis. The study was approved by the local ethics committee in accordance with the Declaration of Helsinki on the use of human subjects in experiments (Government of Upper-Austria; study number: K-27-13).

Trunk inclination as trunk sway area [$(°)^2$] and the corresponding mean trunk angular velocity (°/s) over 20 s were selected as dependent measure variables for all test conditions. Trunk sway area and trunk angular velocity were defined by the envelope of the pitch and rolls excursions when the respective variables were plotted as x–y plots (convex hull).

All data sets of metric variables were checked for normal distribution (Kolmogorov–Smirnov-test). For statistical analysis we used a one-way ANOVA with post hoc-test Games–Howell to validate group differences (tests of homogeneity of variances by Levene statistic was $p > 0.05$). The effects of distraction maneuvers in all stance tasks were analysed by one-way ANOVA with repeated measures (significance level $p < 0.05$). The statistical analysis was performed using the software SPSS for Windows Version 13.0.

Fig. 1. Experimental condition. (a) Subject with the measurement device strapped to his back on a normal surface. (b) Distraction maneuver "write numbers with the index finger on his back".

3. Results

Characteristic features of stance and gait in the twelve patients of the PBG group are given in Table 1, while all main results are shown in Table 2 and Fig. 2.

Across all groups, one-way ANOVA showed significant differences of mean values of trunk sway regarding all eight parameters without distraction (one-way ANOVA: $F \geq 4.125$; $p \leq 0.025$) and during distraction (one-way ANOVA: $F \geq 4.613$; $p \leq 0.017$).

3.1. Trunk sway without distraction

To the other groups, the PBG group showed the highest absolute trunk sway values regarding all parameters. In post hoc tests, the statistically largest difference in mean trunk sway between groups was found under eyes open stance (EO $(°)^2$ mean (SD): PBG vs. MS: 1.65 (0.63), $p = 0.049$; PBG vs. C: 2.47 (0.60), $p = 0.004$, MS vs. C: 0.82 (0.24), $p = 0.010$). Regarding the other seven tested parameters, the PBG group showed significantly worse postural stability compared to healthy controls ($p < 0.05$), but no significant differences compared to the MS group (Fig. 2).

3.2. Trunk sway with distraction

In contrast to the PBG group and healthy controls, the MS group showed a significant increase of trunk sway values in all test situations under distraction (Fig. 2). In post hoc tests, the statistically largest difference in mean trunk sway between the MS group and the other groups was found under eyes closed on foam support (ECF $(°)^2$ mean (SD): MS vs. PBG: 7.31 (2.45), $p = 0.018$, MS vs. C: 12.59 (1.60), $p < 0.001$, PBG vs. C: 5.28 (1.91), $p = 0.043$ and ECF (°/s) mean (SD): MS vs. PBG: 2.41 (0.60), $p = 0.004$, MS vs. C: 3.24 (0.57) $p < 0.001$, PBG vs. C: 0.83 (0.21), $p = 0.004$).

3.3. Distractibility

While there was no significant change in trunk sway values in the MS group and healthy controls under distraction versus without distraction, trunk sway values paradoxically decreased in seven of eight parameters in the PBG group when distracted versus without distraction (Table 2).

To appropriate sensitivity and specificity we defined a cut off value for distractibility (mean + 2 SD in the healthy controls) in all parameters.

In EC and ECF distractibility in the PBG reached 100% sensitivity and 100% specificity in the trunk sway area (cut off EC $(°)^2 = 0.68$; cut off ECF $(°)^2 = 2.02$).

High sensitivity (91.7%) and specificity (91.7%) could be achieved in the trunk angular velocity ECF by a cut off from 0.79 (°/s). In the remaining parameters the sensitivity ranged between 41.7% and 66.7% whereas specificity ranged above 91.7% to 100%. In EO $(°)^2$ (cut off: 0.68) and EO (°/s) (cut off: 0.23). The Sensitivity in the condition eyes open on foam support (EOF) could identified 66.7% PBG in trunk sway area and trunk sway acceleration (seven pass the cut off $(°)^2$ of 1.76 and five the cut off (°/s) of 0.39).

The lowest specificity could be achieved in ECF (°/s) by a cut off value of distractibility by 0.37 (°/s).