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9th International Posture Symposium

Smolenice Castle, Slovakia

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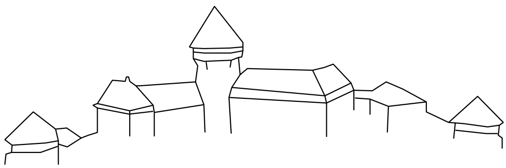
9TH INTERNATIONAL POSTURE SYMPOSIUM



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ABSTRACTS OF THE 9TH POSTURE SYMPOSIUM

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Welcome to the 9th International Posture Symposium

Postural control involves controlling the body's position in space for the dual purposes of stability and orientation and is fundamental to everything we do. It emerges from an interaction of the individual with the task and the environment. Over the past decades, research into posture and balance control and their disorders has hugely shifted and broadened. Our understanding of the underlying neural and sensorimotor mechanisms is changing and will continue to change, in response to emerging research in this field.

The tradition of posture symposiums in Slovakia started in 1971 as a second symposium of the International Society of Posturography (now International Society of Posture and Gait Research, ISPGR). The new series of posture symposium was started by Prof. František Hlavačka, head of the Motor Control Laboratory of the Institute of Normal and Pathological Physiology and Prof. Thomas Mergner from the Neurological

University Clinic in Freiburg, Germany. From the beginning, the symposiums were held in Smolenice Castle, the first in 1992 focused on vestibular-proprioceptive interaction for body orientation in space and the second symposium in 1994 focused on sensory interaction in body posture and movement control. From the third symposium in 2003, the international organizing team was significantly strengthened by Prof. Fay Horak from Oregon Health and Science University, USA and by Prof. Lorenzo Chiari from University of Bologna, Italy. The next symposiums continued in 2006, 2008, 2011, 2015, and 2018.

9th International Posture Symposium was held in the Congress Center of Slovak Academy of Sciences in Smolenice Castle, Slovakia, on September 10-13, 2023. The symposium was opened with the keynote lecture given by prof. Lena H. Ting from Emory University and Georgia Institute of Technology, Atlanta, USA. The symposium offered an opportunity for researchers, clinicians and scientists in the field of human motor control to share their ideas from various points of view and provided a place not only for fruitful scientific discussions, but also for pleasurable social ambience and informality.

LIST OF ORGANIZERS

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Index

Pitch, yaw and roll plane instability during balance tests: Axis differences following acute unilateral vestibular loss

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Citation
Allum, J.H.J., Candreia, C., Honegger, F. Pitch, yaw and roll plane instability during balance tests: Axis differences following acute unilateral vestibular loss.

Introduction

For a number of reasons, clinical dynamic posturography concentrates on pitch and roll and not yaw plane measures. This emphasis may not represent axis instability observed in clinical stance and gait tasks for heathy control subjects and patients with balance deficits, as well as differences between these 2 groups. To examine this question, we measured trunk sway in all 3 directions (pitch, roll and yaw) during stance and gait tasks for healthy controls (HC) and patients with acute unilateral vestibular loss (aUVL).

Methods

Results of 12 patients (mean age 61 years) recorded within 6 days of aUVL onset were compared within those of 8 age-matched HC. All subjects performed a 2-legged stance task, standing eyes closed on foam (S2ecf), a semi-gait task - walking 8 tandem steps (tan8), and 4 gait tasks – walking 3m with head rotating laterally, pitching, or eyes closed (w3hr, w3hp, w3ec), and walking over 4 barriers 24 cm high, spaced 1 m apart (barr). Task peak-to-peak yaw, pitch and roll angles and angular velocities were measured with a gyroscope-system (SwayStar^{TM}) mounted at L1-3 and combined into 3, axis specific, balance control indexes (BCI) using angle measures (a) for the tandem gait and barriers task and angular velocities (v) for all other tasks, that is:

$$BCI = (2*S2ecf)v + (1.5*(w3hr+w3hp+w3ec))v + (tan8+12*barr)a.$$

The asymmetries in posturography BCI values were compared with asymmetries in vestibular ocular reflex (VOR) asymmetries recorded video head impulse tests (vHIT).

Results

Yaw and pitch BCIs were significantly ($p \leq 0.004$) greater (88 and 30 %, respectively) than roll BCIs for aUVL patients (Fig. 1). For HC only yaw but not pitch BCIs were greater ($p=0.002$) than those of roll (72 %). The order of BCI aUVL vs. HC differences was pitch, yaw, and roll: 55, 44 and 31 %, respectively ($p \leq 0.002$). This difference with respect to roll corresponded to the known greater yaw plane than roll plane asymmetry (40 vs. 22 %) following aUVL based on vHIT responses. However, the lower pitch plane asymmetry (3.5 %) in VOR responses did not correspond with the pitch plane instability observed in balance control. The increases in pitch plane instability in aUVL subjects were, however highly correlated with those of roll and yaw (Fig. 2).

Conclusions

These results indicate greater yaw than pitch and roll trunk motion during clinical balance tasks is common for aUVL patients and HC. Asymmetries in VOR responses do not correspond with the greater pitch plane instability observed in balance control. Rather a cross-axis coupling effect may occur. Whether the directional specific recovery processes for balance control and

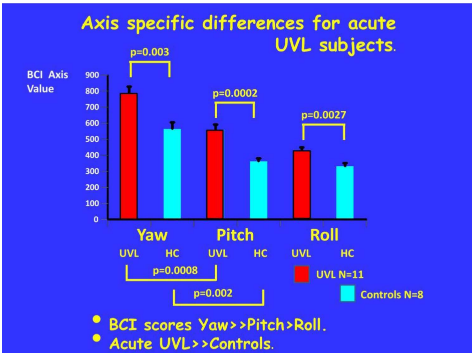

FIGURE 1
Axis specific differences for subjects with acute unilateral vestibular loss (UVL). BCI – balance control index, HC – healthy controls.

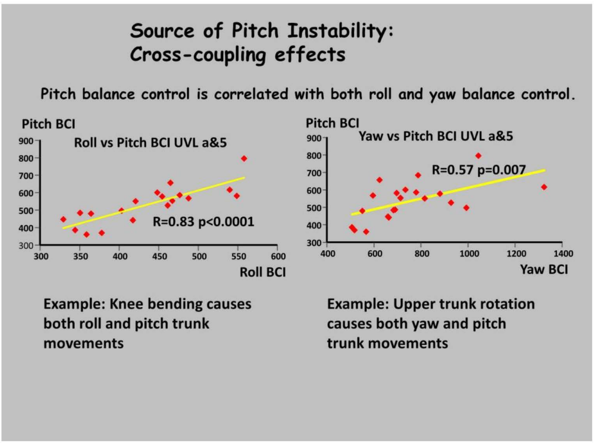

FIGURE 2
Cross-coupling effects between roll, yaw and pitch planes.

VOR responses are similar remains to be investigated. The current results provide a strong rationale for clinical testing of directional specific balance responses, concentrated on pitch and yaw.

The effects of vibro-tactile biofeedback balance training on balance control and dizziness in patients with persistent postural-perceptual dizziness

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Citation
Allum, J.H.J., Candreia, C., Rust, H.M., Honegger, F. The effects of vibro-tactile biofeedback balance training on balance control and dizziness in patients with persistent postural-perceptual dizziness.

Introduction
Patients with persistent postural-perceptual dizziness (PPPD) frequently report having problems with balance control. Artificial systems providing vibro-tactile feedback (VTfb) of trunk sway to the patient could aid recalibration of "falsely" programmed natural sensory signal gains underlying unstable balance control and dizziness. Thus, the question we examine, retrospectively, is whether such artificial systems improve balance control in PPPD patients and simultaneously reduce the effects of dizziness on their

living circumstances. Therefore, we assessed in PPPD patients the effects of VTfb of trunk sway on balance control during stance and gait tests, and on their perceived dizziness.

Methods

Balance control was assessed in 23 PPPD patients (11 of primary PPPD origin) using peak-to-peak amplitudes of trunk sway measured in the pitch and roll planes with a gyroscope system (SwayStar™) during 14 stance and gait tests. The tests included standing eyes closed on foam, walking tandem steps, and walking over low barriers. The measures of trunk sway were combined into a Balance Control Index (BCI) and used to determine whether the patient had a quantified balance deficit (QBD) or dizziness only (DO). The Dizziness Handicap Inventory (DHI) was used to assess perceived dizziness. The subjects first underwent a standard balance assessment from which the VTfb thresholds in eight directions, separated by 45 dgs were calculated for each assessment test based on the 90 % range of trunk sway angles pitch and roll directions for the test. A headband-mounted VTfb system, connected to the SwayStar™, was active in one of the eight directions when the threshold for that direction was exceeded. The subjects trained for 11 of the 14 balance tests with VTfb twice per week for 30 min over a total of 2 consecutive weeks. The BCI and DHI were reassessed each week and the thresholds were reset after the first week of training.

Results

On average, the patients showed an improved balance control in individual tests as well as the global BCI values after 2 weeks of VTfb training (24 % $p=0.0001$), Fig. 1. The improvement was greater for the QBD patients than for the DO patients (26 vs. 21 %), and greater for the gait tests than the stance tests. After 2 weeks, the mean BCI values of the DO patients, but not the QBD patients, were significantly less ($p=0.0008$) than the upper 95 % limit of normal age-matched reference values. A subjective benefit in balance control was spontaneously reported by 11 patients. Lower (36 %), but less significant DHI values were also achieved after VTfb training ($p=0.006$). The DHI changes were identical for the QBD and DO patients and approximately equal to the minimum clinical important difference.

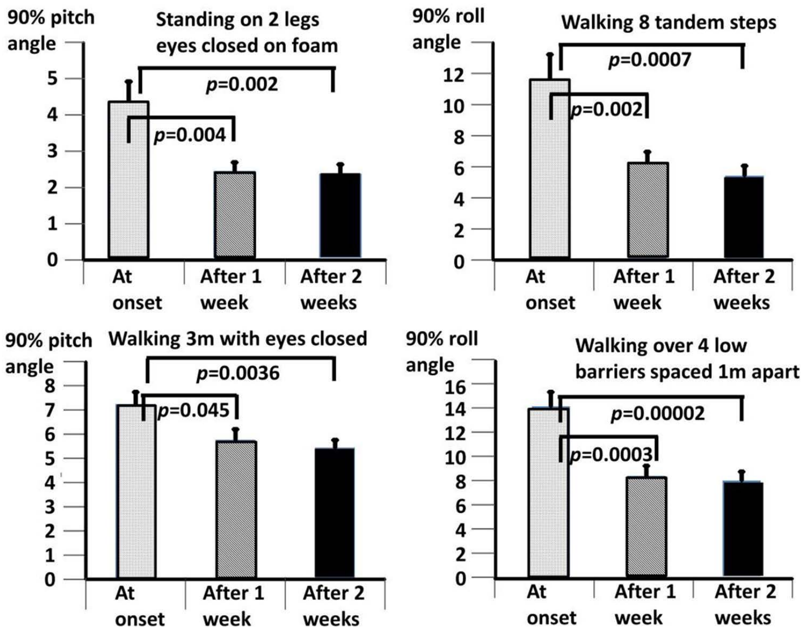

FIGURE 1
Changes in 90 % ranges of trunk sway angles after 1 and 2 weeks of VTfb training for 2 eyes closed trials (standing eyes closed on foam and walking 3 m eyes closed) and 2 difficult gait tasks (walking tandem steps and walking over low barriers). Combined (DO and QBD) population values are shown in each set of column plots. The mean population value is represented by the height of the column in each column plot and the standard error of the mean (sem) by the vertical bar on the top of each column. Significant differences between mean onset (baseline) values and mean values after 1 and 2 weeks of training are marked by horizontal bars and the respective t-test probability (p) values. There were no significant differences between mean values after 1 and 2 weeks of VTfb training.

Conclusions

These initial results show, as far as we are aware for the first time, that providing VTfb of trunk sway to PPPD subjects yields a significant improvement in balance control, but a far less significant change in

DHI-assessed dizziness. The intervention benefitted the gait trials more than the stance trials and benefited the QBD group of PPPD patients more than DO group. This study increases our understanding of the pathophysiological processes underlying PPPD and provides a basis for future interventions examining perceptual rather than enhanced sensory gains of PPPD patients.

Sensory reweighting on foam and tilting surfaces

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Citation
Assländer, L., Lörch, M., Albrecht, M., Streuber, S., Gruber, M. Sensory reweighting on foam and tilting surfaces.

Introduction
Humans shift sensory contributions depending on context, reliability and availability of individual sensory cues. The assessment of disorders in this sensory reweighting process is of broad interest for patient populations with an increased risk of falling. Quantitative assessments of the sensory contribution, however, require systematic perturbations [1], which are experimentally difficult to implement. In recent studies, we demonstrated, that moving screen paradigms used to assess visual sensory contributions can be implemented with state-of-the-art virtual reality systems, thereby largely reducing the experimental requirements [2]. However, available VR systems are purely visual and do not allow for the assessment of proprioceptive and vestibular sensory weights. In the study presented here, we explored to what extend foam surfaces in combination with virtual moving screen paradigms can be used for a quantitative assessment of visual and proprioceptive sensory contributions.

Our design followed a four-step rational: 1) foam has been shown to down-weight proprioception, where thicker foam leads to a higher reduction. 2) Analogously, support surface tilts result in proprioceptive down-weighting, with larger tilt amplitudes increasing the effect. In addition, tilt perturbations can be used for quantitative assessments of the proprioceptive weight. 3) Visual scene movements lead to a visual down-weighting and can be used to quantify the visual weight. 4) As sensory weights interact, where down-weighting of one system necessitates the up-weighting of other systems, changing surface tilt amplitudes and visual scene amplitudes on the one side, and foam thickness and visual scene amplitudes on the other side, might reveal mutual systematic changes. Given the existence of a common reweighting pattern between standing on foam and on a tilting surface, combining foam and virtual-reality moving screen experiments could be sufficient for the quantitative assessment of visual and proprioceptive weights.

Methods

Twenty subjects (8 female, 12 male) completed a total of 10 conditions on a custom-built motorized platform and wearing a virtual reality (VR) head mounted display. Subjects looked at a screen in the virtual environment, which was translating in anterior-posterior (ap) direction following a 20-s long pseudo-randomized sequence either with a peak-to-peak amplitude (pp) of 1.5 cm or 3.0 cm. Each visual condition was combined with 5 different surface conditions: 1) fixed and firm surface; 2) a 40-s long pseudo-random surface tilt of pp 1.5° or 3) pp 3.0° where the tilt amplitude was linearly independent of the visual tilt amplitude, allowing us to separate the sway evoked by surface and visual tilt stimuli during the analysis; 4) thin foam (6.5 cm); 5) thick foam (10 cm). We recorded anterior-posterior body sway and calculated body center of mass movements as the primary variable for all further analysis. Each condition had a total duration of 280 s, comprising 14 visual sequence cycles and – during the surface tilt conditions – 7 surface sequence cycles. We used model-based interpretations of the sway responses evoked by the stimuli, as described by Peterka et al. [3] to extract sensory contributions.

Results

Results showed the expected reweighting-behavior, where thicker foam and an increase in the surface tilt amplitude led to an increase in the visual weight. Increasing the surface tilt amplitude led to a reduction of the proprioceptive weight. While these results looked very systematic and consistent on a group level, visual reweighting of individual subjects largely differed between the foam and the surface tilt manipulations. For example, down-weighting of the visual contribution when increasing the visual stimulus amplitude was much larger on foam as compared to surface tilt conditions in some subjects and smaller in other subjects. Also, while proprioception was down-weighted in all subjects, when increasing surface tilt amplitudes, simultaneously assessed visual weights showed an up-weighting only in some subjects, while other show little to no increase, indicating an up-weighting of the vestibular contribution.

Conclusions

In conclusion, compensation of proprioceptive down-weighting shows large inter-individual differences in the extent the visual and/or the vestibular system are up-weighted. Furthermore, subjects' visual contribution is affected differently when changing foam-thickness as compared to changing surface tilt amplitudes. Therefore, inferences from visual reweighting on foam to proprioceptive reweighting seem to be impossible without additional proprioceptive and/or vestibular perturbations.

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Effect of cognitive task on complexity of walking in typically developing children and children with developmental coordination disorder

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Citation
Bizovska, L., Svoboda, Z., Klein, T., Banatova, K., Valtr, L., Abdollahipour, R., Wilson, P.H. Effect of cognitive task on complexity of walking in typically developing children and children with developmental coordination disorder.

Introduction

Non-linear approach for data analysis of basic daily life activities including stance and gait is now common, evaluating the inner structure of data [1], including the assessment of variability and complexity of the observed time series. Sample entropy is one measure of gait that describes complexity of the movement with the overlap into evaluation of automaticity of the performance [2]. Entropy measures have been used widely to evaluate the development of mature adult gait [3,4]. However, little is known about the effects of a secondary cognitive task on gait in children with motor difficulties. The aim of this study is to evaluate the effect of cognitive task on children that are typically developing (TD) and children with diagnosed developmental coordination disorder (DCD).

Methods

204 children (TD and DCD) aged 7-12 years participated in this study, divided into 3 age groups (7-8; 9-10 and 11-12 years old). Children with DCD were screened using the Movement Assessment Battery for Children 2nd edition. Children were asked to walk a 20-m long corridor in a repeating circuit (4 times) at their preferred walking speed, without stopping. This was completed in two conditions: a) while instructed not to speak, b) while performing a secondary cognitive task (i.e., verbal fluency test). Children were equipped with an inertial sensor (Physilog v5, GaitUp, Lausanne, Switzerland) attached directly to the skin by a double-sided tape on the lower back at the level of the 5th lumbar vertebra. Turns at the end of the corridor were identified based on the behavior of the angular velocity signal around vertical axis and cut-off from the signal together with one stride before and after the turn. Afterwards, linear accelerations in vertical (V), medial-lateral (ML) and anterior-posterior (AP) directions were used for further analysis. After identification of heel strikes based on the procedure introduced by [5], middle 54 steps were filtered by the 4th order low-pass Butterworth filter with a cut-off frequency of 20 Hz and used for a computation of sample entropy (input variables $m=2$, $r=0.15$). Dual-task cost (DTC) was computed as follows: [(dual task result – single task result)/ (single task result)] x 100. Statistical analysis was performed on sample entropy by mixed-way analysis of variance (ANOVA) with age (7-8; 9-10 and 11-12 years) and group (DCD, TD) as between subject factors and task (single, dual) as a within subject factor. Pair-wise comparison was performed by the Bonferroni post-hoc test. DTC was compared by two-way ANOVA with age (7-8; 9-10 and 11-12 years) and group (DCD, TD) as factors.

Results

Table 1 shows descriptive results for sample entropy. A task effect was found in V and ML directions ($p<0.001$ for both). In AP direction, groups differed (p=0.007) while in the V direction, the group x task interaction was significant. Sample entropy was reduced under dual-task conditions in the V direction for all age groups of TD children and youngest group of DCD children. No other significant differences were revealed by a post-hoc test. Statistical analysis did not show any significant effect of age nor group for DTC.

TABLE 1: Sample entropy results for single and dual task walking presented as mean ± standard deviation

Age group	Direction of movement	Group	Single task	Dual task
7-8 years	V	DCD	0.88 ± 0.12	0.73 ± 0.10
		TD	0.85 ± 0.13	0.78 ± 0.14
	ML	DCD	0.71 ± 0.10	0.66 ± 0.11
		TD	0.67 ± 0.12	0.66 ± 0.12
	AP	DCD	0.62 ± 0.11	0.63 ± 0.10
		TD	0.62 ± 0.14	0.63 ± 0.11
9-10 years	V	DCD	0.87 ± 0.13	0.79 ± 0.12
		TD	0.85 ± 0.13	0.79 ± 0.13
	ML	DCD	0.72 ± 0.12	0.67 ± 0.10
		TD	0.67 ± 0.13	0.64 ± 0.14
	AP	DCD	0.70 ± 0.10	0.67 ± 0.12
		TD	0.62 ± 0.13	0.61 ± 0.13
11-12 years	V	DCD	0.88 ± 0.16	0.80 ± 0.16
		TD	0.90 ± 0.13	0.83 ± 0.17
	ML	DCD	0.74 ± 0.10	0.72 ± 0.15
		TD	0.70 ± 0.12	0.66 ± 0.12
	AP	DCD	0.70 ± 0.14	0.72 ± 0.20
		TD	0.62 ± 0.15	0.60 ± 0.14

Note. AP – anterior-posterior, DCD – children diagnosed with developmental coordination disorder, ML – medial- lateral, TD – typically developing children, V – vertical

Conclusions

Complexity of gait represented by sample entropy values decreased when performing a secondary cognitive task, compared with walking alone. Lower values are usually considered to represent worse adaptability or lower automaticity of the movement performance. Interestingly, age and presence of a developmental coordination disorder did not affect sample entropy values significantly, consistent with a relatively low-level of task complexity.

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Towards clinical assessment of fall-injury risk: Push-off and handgrip strength are associated with the energy absorption capacity of the arms in older adults

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Citation
Bray, A., Srour, A., Raccioppi, J., Jeon, W., Hsaio, H., Rogers, M.W., Borrelli, J. Towards clinical assessment of fall-injury risk: Push-off and handgrip strength are associated with the energy absorption capacity of the arms in older adults.

Introduction
Falls are a leading cause of injury and death in older adults. Fall injuries occur when balance recovery mechanisms fail, and the impact energy surpasses the body's capacity for absorption. While various methods exist to assess

balance recovery capacity and fall risk, there are currently no effective approaches to assess fall-injury risk. Protective arm reactions are one of the important compensatory responses available to reduce the risk of fall-injury. This study aims to investigate the association between clinically accessible measures of strength and mobility and the arm's energy absorption capacity.

Methods

Ten younger and nine healthy older adults (over 55 years of age) participated in this IRB approved study (Table 1). Participants were assessed using a handgrip dynamometer and performed a handgrip test, push-off test, the Falls Risk for Older People – Community Setting survey, the Mini-Balance Evaluation Systems test (mini-BESTest), the four-square step test (FSST), and the timed up and go test (TUG). Participants also performed a countermovement push-up, beginning and ending with their arms extended, as fast as possible. The push-up test, handgrip strength test, and push-off test were repeated three times with sufficient breaks provided between trials. The energy absorption rate during the lowering phase of the push-up was normalized to the participant's height and weight. Participants that were unable or unwilling to perform a push-up were assumed to have an energy absorption rate of zero. A t-test was used to compare strength and balance measures between younger and older adults. The average value was used for handgrip strength and push-off strength. Repeated measures ANOVA was used to compare the energy absorption rate between younger and older adults. Pearson correlation was used to identify associations between the energy absorption rate for older adults and the outcome measures.

Results

Older adults did not score as well on the mini-BESTest or FSST as younger adults. Older adults also exhibited a significantly reduced energy absorption rate than younger adults (Table 1). Push-off strength and handgrip strength were identified as the strongest predictors of the energy absorption rate in older adults (R^2>84%, Table 1).

TABLE 1: Mean and standard deviation participant characteristics

	Younger Adults	Older Adults	p-value	Correlation with energy absorption rate for older adults (R^2)
n (# females)	10 (4)	9 (3)	-	-
Age	20.6 (1.8)	69.9 (8.0)	-	-
Weight (kg)	67.9 (14.5)	79.4 (13.7)	0.10	-
Height (cm)	1.72 (0.11)	1.74 (0.07)	0.64	-
Handgrip Strength (kg)	36.0 (12.1)	31.5 (10.4)	0.40	0.85
Push-Off Strength (kg)	34.3 (13.1)	23.5 (9.9)	0.06	0.86
Falls Risk for Older People	3.8 (4.2)	4.2 (2.6)	0.80	0.17
Mini Balance Evaluation Systems Test	26.9 (1.4)	24.2 (3.5)	0.04	0.09
Four-Square Step Test (s)	6.17 (1.6)	8.4 (2.6)	0.04	0.17
Timed Up and Go (s)	9.1 (1.5)	9.6 (2.5)	0.61	0.15
Energy Absorption Rate (N-m/s/kg/m)	-0.46 (0.13)	-0.21 (0.24)	0.003	-

Conclusions

This study supports previous findings that older adults have a lower energy absorption capacity than younger adults [1–3]. This preliminary study establishes a relationship between the energy absorption capacity of the arms and the push-off test and handgrip strength. However, more work is required to identify a threshold or cut-off between the energy absorption capacity of the arms and fall-injury risk. Despite the mean value for the clinical tests indicating that there were mostly no age-related differences, three older adults showed increased fall risk based on a history of falling, mini-BESTest score, or TUG score [4–7]. Two older adults reported falling in the past year and one older adult had a mini-BESTest score of 16/28, took more than 12 s to complete the TUG (14 s), and reported falling in the past year. There are methods of decreasing fall risk among older adults however it is not known if fall-injury risk is affected or requires specific intervention. Avoiding injury in an unavoidable fall requires a well-timed and coordinated full-body response. The arm's energy absorption capacity is likely one of several factors affecting successful injury avoidance in an unavoidable fall. Future work is required to better understand the factors contributing to effective injury avoidance in unavoidable falls and establish intervention thresholds. The aim of this work was to identify a clinically accessible method of assessing fall-injury risk. This first step has demonstrated a relationship between the arm's energy absorption capacity and the clinically measurable quantities, handgrip strength and push-off strength. However, avoiding fall-related injury is a multi-factorial task, and a more comprehensive assessment method is required.

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Individual height intolerance affects postural control during the virtual height exposure

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Bzdúšková, D., Marko, M., Hirjaková, H., Kimijanová, J., Hlavačka, F., Riečanský, I. Individual height intolerance affects postural control during the virtual height exposure.

Introduction

Today, virtual reality (VR) is widely used in many different fields and populations because it provides realistic, standardized, repeatable and controllable environments. The VR allows placing individuals in a variety of environments that are not easily accessible in real life or that they might avoid due to fear or safety constraints, such as height. Growing evidence suggests that the height represents a postural threat and a natural stressor, inducing changes in postural control as well as activation of the sympathetic nervous system [1,2]. Because approximately 30 % of the adults suffer from visual height intolerance, which causes behavioral constraints and avoidance of exposure to heights [3], there is need to investigate the changes in the postural control and the psycho-physiological markers of stress due to the height exposure in individuals with varying sensitivity to the stressor.

Methods

We evaluated postural and psycho-physiological parameters in 42 young volunteers (mean age 27.0 $\pm$ 6.1 years) with varying intensity of fear of heights while standing on an unstable support surface at height in a virtual reality environment [4]. Virtual open-air elevator was used for height simulation and the measurements were carried out at ground level and at virtual heights of 20 m and 40 m. We also explored the dynamics of postural responses in the condition of enhanced postural threat in forward direction using bilateral vibration of tibialis anterior muscles (with duration of 7 sec, frequency of 80 Hz, amplitude of 1 mm).

Results

The height exposure in VR evoked increased distress, heart rate and electrodermal activity, which was more pronounced in individuals suffering from fear of heights compared with individuals with low fear of heights.
In static balance conditions, higher velocity of postural sway as well as decreased low- frequency (<0.5 Hz) and increased high-frequency (>1 Hz) sway oscillations were found [4]. In dynamic conditions, reduced vibration-induced body tilt in forward direction and restricted postural sway during

vibration were seen under the threat of height. The magnitude of body sway and vibration-induced body tilt was overall smaller in individuals suffering from fear of heights compared to participants with low fear of heights.

Conclusions

The height exposure elicited a complex, robust, and reliable psycho-physiological response with significant changes in emotional state, sympathetic activity, and postural control that were enhanced in individuals with a fear of heights. In static conditions, we observed rigid and stiffened posture characterized by higher velocity and simultaneously smaller magnitude of body sway in individuals with fear of heights [4]. In dynamic conditions (combination of height and involuntary body tilt in the direction facing the threat of height), restricted body sway during stimulation was found in both groups, however the individuals with higher fear showed more stiffened posture with smaller forward body tilt, reduced magnitude and simultaneously increased velocity of body sway. Therefore, when assessing postural stability in a stressful environment, it is particularly important to take into account currently experienced fear, which obviously affects postural responses in threatening situations with a potential risk of falling.

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Subjective visual vertical and postural control in patients following cochlear implantation

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Citation
Čakrt, O., Slabý, K., Kučerová, K., Jeřábek, J., Bouček, J. Subjective visual vertical and postural control in patients following cochlear implantation.

Introduction

Cochlear implantation (CI) is associated with changes in the histopathology of the inner ear and impairment of vestibular function. The objectives of our study were to evaluate patients for clinical manifestations of vestibular and balance changes before surgery, compare them with asymptomatic subjects (controls), and report changes in posturography and subjective visual vertical (SVV) during the acute post-surgery period in patients.

Methods

Examination was performed using posturography and the SVV measurement. We examined 46 control subjects and 39 CI patients pre-surgery (Pre). Patients were examined 2nd day (D2) and then 14th day (D14) after surgery.

Results

Baseline SVV was not different between patients and control group. There was a statistically significant difference ($p<0.001$) in SVV between subgroups of right- and left- implanted CI at D2 (-1.36 ± 3.02° and 2.71 ± 2.36°, right and left side implanted respectively) but not Pre (0.76 ± 1.07° and 0.31 ± 1.82°) or D14 (0.72 ± 1.83° and 1.29 ± 1.60°). Baseline posturography parameters between patients and control group were statistically significantly different ($p<0.05$). There was no statistically significant difference in posturography among Pre, D2 and D14.

Conclusions

CI candidates have impaired postural control before surgery. CI surgery influences perception of subjective visual vertical in acute post-surgery period with SVV deviation contralateral to side of cochlear implantation, but not after two weeks.

Long-term posturography by wearable accelerometers: 15 years later

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Chiari, L., Albites Sanabria, J., Palumbo, P., Helbostad, J.L., Bandinelli, S., Mellone, S., Palmerini, L. Long-term posturography by wearable accelerometers: 15 years later.

Introduction

This study is an updated retelling of an exploratory study presented in this forum fifteen years ago [1]. The new study focuses on postural control and balance assessment in older adults, specifically in real-world scenarios. We aimed to develop and validate a tool for assessing balance in real-world conditions using wearable inertial sensors placed at the lower back. The study involved two cohorts of community-dwelling older adults: the ADAPT (A Personalized Fall Risk Assessment System for promoting independent living) [2] and the InCHIANTI ("Invecchiare nel Chianti") [3] studies.

Methods

We developed a finite-state machine (FSM) algorithm that classified four states: walking, turning, sitting, and standing, and validated the FSM algorithm against video annotations as the gold standard. The validation was performed on data collected from 20 older adults in the ADAPT study (76.4 ± 5.6 years). Subsequently, the FSM algorithm was applied to data from 168 community-dwelling older people in the InCHIANTI cohort (79.7 ± 6.6 years). These participants were assessed both in the laboratory and continuously monitored remotely for a week in real-world settings.

Results

Not surprisingly, the study findings indicate that real-world balance characteristics differ significantly from laboratory-based assessments. Figure 1 illustrates representative traces (ellipse area) for a lab assessment and a real-world measurement during a standing event. The size and jerkiness of the accelerometer traces are larger during real-world assessments. Measurements were significantly different under the Wilcoxon signed rank test ($p<0.05$) between the two settings, with spatiotemporal features being significantly larger under real-world conditions. Antero-posterior and mediolateral ranges and ellipse areas obtained in real-world settings showed an increase of over 50 % compared to laboratory measurements (Fig. 2). In addition, no significant correlations were found between real-world and laboratory balance features except for weak correlations in mean frequency ($r=0.239$), jerk ($r=0.233$), and spectral centroid ($r=0.214$). Interestingly, the balance features extracted from real-world data were found to be more predictive of fall risk in older adults than those obtained from laboratory-based assessments. The area under the curve (AUC) of a Lasso model built on real-world features was 0.76, whereas the AUC of a model built on lab-based

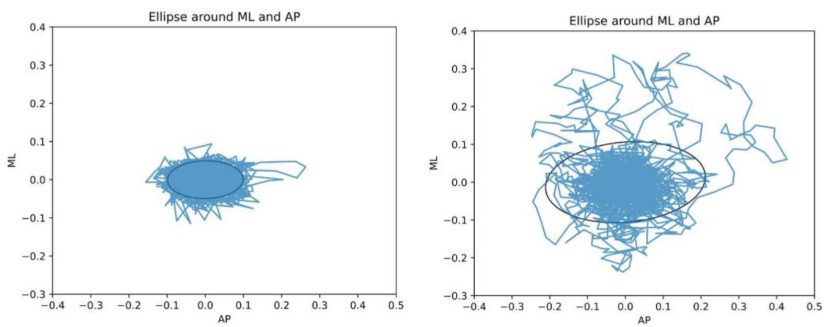

FIGURE 1
Ellipse area representative traces for a 30 s lab (left) and a 30 s real-world assessment (right).

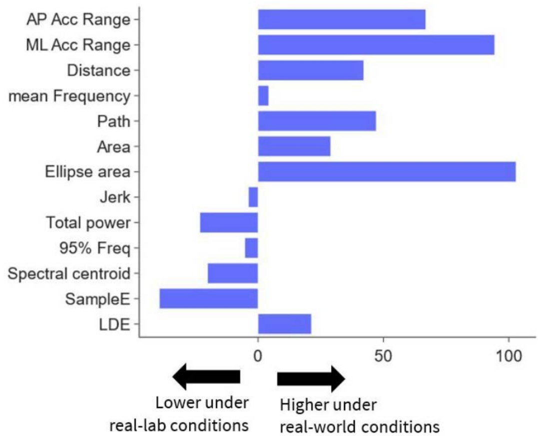

FIGURE 2
Percentage change from parameters measured under real-world conditions compared with in-lab conditions.

assessments was 0.57. These results suggest the need to move away from traditional laboratory-based balance measures and develop more sensitive and accurate methods for predicting falls.

Conclusions

The study contributes to the understanding of postural control and balance assessment in older adults by highlighting the importance of assessing balance in real-world scenarios. The use of wearable sensors and the development of the FSM algorithm provide a potential tool for objective and quantitative balance assessment outside the controlled laboratory environment. Overall, real-world balance features showed better prognostic ability in identifying individuals at high risk of falling. These findings highlight the need to move beyond traditional laboratory-based balance measures and, e.g., develop more sensitive and accurate methods for predicting falls. Lab-based assessments may indeed not accurately reflect daily life's demands and may not capture the full range of balance challenges that older adults encounter. Furthermore, unlike lab assessments, real-world assessments allow for the identification of multiple events, providing additional insights into the participants' exposure and fitness.

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The los test in the assessment of functional stability in obese women after weight reduction

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Cieślińska-Świder, J., Błaszczyk, J., Opala-Berdzik, A. The los test in the assessment of functional stability in obese women after weight reduction.

Introduction

An increase in adipose tissue, besides many health complications, alters human motor behavior resulting in the decline of quality of life. One of the scientifically detected changes is a deterioration of postural stability that impacts almost entire human motor behavior. The static postural stability in the obese population has been well known. However, testing the quiet standing postural control does not give a complete view of overall postural stability. Functional stability, which is necessary for everyday activities, can be also reliably assessed using the limits of stability (LOS) test [1]. The LOS is referred to the maximum voluntary displacement of the center of gravity (COG) in a given direction that can be controlled without a loss of equilibrium. To examine functional stability on the force platform, the center of pressure (COP) excursions towards the anatomically defined limits of the base of support are recorded. During the dynamic transition from quiet standing to maximal forward-leaning position, in addition to the range of leaning, velocity of leaning can provide a better insight into the control of the postural stability [1]. The studies have shown that during the LOS test the obese subjects presented a reduced range of forward-leaning [2-4] and a reduced average [3,4] and maximal [4] velocity of leaning compared to subjects with normal BMI. The purpose of the present study was to determine whether participation in the three-month weight-loss program that led to body mass reduction influenced the results of the anterior LOS test in young obese females. The specific goal was to compare the parameters related to the dynamic transition from standing to maximal forward-leaning and to the maintenance of maximal forward-leaning position before and after the weight loss. Our main hypothesis was that the body mass reduction would improve functional stability by increasing the anterior LOS and by increasing COP velocity during the anterior LOS test.

Methods

The data of 30 obese females were considered. The inclusion criteria were the age of 45 years or younger, body mass reduction equal to or greater than 5 % of the initial body mass. The mean age of the subjects was 35.8±9.2 years, the mean body mass (initially) was 94.9±13.4 kg and mean BMI was 36.1±5.1 [kg/m^2]. To perform the anterior LOS test, subjects were asked to stand barefoot and at a comfortable stance on the force platform keeping hands along the torso. Each subject was instructed to perform 30-s trials with eyes open looking straight ahead at the wall that was three meters away and then with eyes closed. The task was to stand as still as possible (for 10 s), and then for a sound signal, to lean forward at a comfortable speed as far as possible by flexing ankle joints (without lifting heels or flexing hips), and maintain this position till the end of the trial (for about 20 s). The Kistler 9281C force platform was used to record the ground reaction forces and the moments around the sagittal and frontal axis, based on which the COP was calculated (BioWare 2.0 software). In this study one phase was analyzed: the dynamic transition from standing to maximal forward-leaning; measured COP parameters: COP mean velocities (Vmean AP, ML, and Total), COP maximal velocities (Vmax AP, ML, and Total), Lean Range - the range of COP anterior excursion.

Results

For the results, please see Table 1.

TABLE 1: Center of foot pressure parameters acquired during dynamic transition from standing to maximal forward-leaning phase of the anterior limit of stability test with eyes open in 30 obese women before and after the three-month weight loss program

Obese Group	Dynamic transition from standing to maximal forward-leaning phase						
	Vmean AP (mm/s)	Vmean ML (mm/s)	Vmean Total (mm/s)	Vmax AP (mm/s)	Vmax ML (mm/s)	Vmax Total (mm/s)	Lean Range (mm)
Before	48.8±25.8	2.6±6.2	49.3±25.8	**140±55.3**	**25.4±16.2**	**141.5±55.4**	81.1±21.3
After	53.6±26.5	1.8±7.9	52.6±26.7	**166.1±40.6**	**35±17.4**	**167.6±41.3**	79.6±16.9
p≤	NS	NS	NS	**0.01***	**0.001***	**0.01***	NS

**The non-parametric Wilcoxon signed-rank test*

Conclusions

As a result of the body mass reduction, the COP velocity parameters related to the LOS test increased in the obese women in normal visual conditions. This may indicate improved mobility and postural control after body mass reduction. Longer lasting weight loss program might be necessary to improve postural control of the young obese women under more challenging conditions such as performance of the LOS test with eyes closed. In addition to therapeutic measures for metabolic reasons, body mass should be reduced in obese patients to improve their mobility and functional stability. It may protect them against unexpected falls and improve their daily activities.

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Human muscle and spinal activation in response to loading

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Clarke, B., Khalid Al-Hammdany, J., Di Giulio, I., Human muscle and spinal activation in response to loading.

Introduction

Standing is the anatomical and functional framework for independent movement. Control of standing and walking is regulated at multiple levels, including supraspinal, spinal and peripheral sensory-motor integration. Pioneering electromyography work has identified key postural muscles during standing [1], including posterior leg and thigh muscles [2-5]. Despite the small sample size, large inter-individual variation and a limited statistical analysis of these seminal studies, there has been limited further work in this field, in part because there has been limited clinical need for further knowledge. With the advent of spinal stimulation for walking restoration in spinal cord injury survivors, there is a need to understand standing's basic requirements, as rhythmic stepping restoration seems successful, but independent weight bearing remains elusive. In this study, muscle activation was measured at different body loadings and the spinal activation was calculated in a group of healthy individuals.

Methods

Muscle activity was recorded in 18 participants (11 males, 7 females; mean±SD 23.6±8.4 years, 1.722±0.122 m, 70.0±15.8 kg) using surface electromyography (EMG) electrodes (Avanti, Delsys Inc, Boston, US). Participants were supine on a motorised plinth and muscle activity was recorded at different body angles: 0 deg (supine), 15 deg corresponding to ~26 % of total body weight (BW), 30 deg (~50 % BW), 45 deg (~71 % BW), 60 deg (~87 % BW), 75 deg (~97 % BW), upright on the plinth (~100 % BW), and upright off the plinth. Muscle activity was recorded for 30 s from soleus, gastrocnemius medialis and lateralis, tibialis anterior, adductor longus, peroneus longus, vastus medialis and lateralis, rectus femoris, sartorius, extensor digitorum longus, semimembranosus, semitendinosus, biceps femoris, gracilis, rectus abdominis, erector spinae, and latissimus dorsi. From muscle activity, spinal activation maps were calculated using the formula [6]

$$\text{Spinal Segment Activation} = \frac{\sum k * EMGi}{n},$$

where EMGi was the muscle activation from the individual muscle, n was the number of muscles contributing to the calculation of the spinal segment activation, and k was 0.5 or 1 according to accepted values published by Kendall et al. [7]. The experiment was in accordance with the Declaration of Helsinki and was approved and conformed to the standards outlined by the King's College London ethics committee (MRA-19/20-14388).

Results

We found a high variability in EMG data, and the group analysis showed that muscle activity changed with body angle. Vastus lateralis became activated at 60 deg (~87 % BW), soleus became activated at 75 deg, and the gastrocnemii at 90 deg. The spinal segments that showed significant differences in mean activation between angles were the fifth lumbar L5 and the first sacral S1 segments.

Conclusions

Weight-bearing independent standing could be achieved with increased activation of a limited number of superficial muscles tested. A critical loading for increased muscle activation compared to the supine position was 87 % BW. The lower lumbar and sacral segments activation suggests their involvement in maintaining weight-bearing standing.

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A back muscle surface electromyography-based fatigue index as a biomarker of human neuromuscular aging

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Ebenbichler, G., Habenicht, R., Blohm, P., Bonato, P., Kollmitzer, J., Mair, P., Kienbacher, T. A back muscle surface electromyography-based fatigue index as a biomarker of human neuromuscular aging.

Introduction

As part of our quest for non-invasive biomarkers of neuromuscular aging and encouraged by recent findings in healthy volunteers, in this study, we investigated if the instantaneous median frequency (IMDF) derived from back muscle surface electromyographic (SEMG) data recorded during cyclic back extensions could differentiate between younger and older individuals with chronic low back pain (cLBP).

Methods

A total of 243 persons with cLBP participated in three experimental sessions: at baseline, one or two days after the first session, and then again approximately six weeks later. During each session, study participants used a dynamometer to perform a series of three isometric maximal voluntary contractions (MVC) of back extensors, followed by an isometric back extension at 80 % MVC, and - after a break - 25 slow cyclic back extensions at 50 % MVC. SEMG data was recorded bilaterally at L5 (multifidus), L2 (longissimus dorsi), and L1 (iliocostalis lumborum). A linear mixed-effects model with fixed effects for "age", "sex", and "test number" and random effects for "person" was used to test for age and sex specific differences in the slope of the IMDF-SEMG, as derived from the regression line of the IMDF-SEMG estimates computed for the concentric phases of the cyclic back extensions. The Generalizability Theory was used to examine the reliability of the SEMG measures.

Results

Perceived back muscle fatigue at the end of the test was moderate in both groups. The IMDF-SEMG time-course showed more rapid changes in younger than in older individuals, more prominently in male participants. Absolute and relative reliability of the SEMG time-frequency representations were comparable in older and younger individuals with overall good relative reliability but variable absolute reliability levels.

Conclusions

IMDF-SEMG estimates derived from data collected during moderately demanding cyclic back extensions proved successful in reliably distinguishing back muscle function in younger vs. older men and - to a smaller extent - in women with cLBP. We look upon these findings as the basis for further research with focus on assessing if an IMDF-SEMG-based index could be utilized as a tool to achieve early detection of back muscle aging and possibly predict the development of sarcopenia.

Assessment of mild hemiparesis in stroke survivors by angular velocity

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Citation
Haltmar, M., Kolářová, B., Haltmar, H., Richards, J. Assessment of mild hemiparesis in stroke survivors by angular velocity.

Introduction

Several clinical assessments are available to objectify the level of hemiparesis in stroke survivors. However, most of these assessments are burdened by subjective assessor error. One way to objectify the difference between the paretic and nonparetic upper limb, or the level of motor recovery of the paretic upper limb, is the use of gyroscopes [1]. Therefore, we focused on evaluating the difference between paretic and nonparetic upper limbs when stroke survivors performing functional movement of upper limbs.

Methods

A total of 18 subacute stroke survivors (66.6 ± 8.5 years, 12 women and 6 men) with mild hemiparesis after first ever stroke were included in the study. The main criterion for inclusion in this study was a score of more than 53 on the Fugl-Meyer Assessment - Upper Extremity (FMA-UE) [2]. Functional movement called as reaching task consists of following steps: a) starting position, b) movement forward to the target and back to starting position, c) end of one repetition (Fig. 1).

Between each series there was a two-minute pause filled with motor imagery of reaching task or nonmotor imagery task. The maximum values from the middle five trials (trials 3-7) of each series were averaged to assess the angular velocity of the arm during flexion and extension. The range of angular velocity was calculated as the absolute difference between the values of flexion and extension angular velocity. The obtained gyroscopic data were statistically evaluated by MM Anova with $p<0.05$.

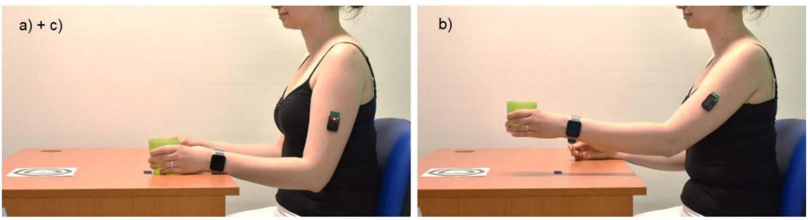

FIGURE 1
Reaching task.

Results

The stroke survivors included in the study received 60.6 out of 66 points in FMA-UE. There was a statistically significant difference in observed angular velocities of the arm (flexion angular velocities of arm: paretic 66.8 °/s, nonparetic 84.6 °/s, p=0.002; extension angular velocities of arm: paretic -65.3 °/s, nonparetic -91.9 °/s, p=0.001; range of angular velocities of arm: paretic 135.1 °/s, nonparetic 177.1 °/s, p=0.001).

Conclusions

The results of this study suggest that angular velocity appears to be a sensitive indicator of poorer motor control of paretic upper limb in subacute patients after stroke.

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Gait imagery in the context of postural stability

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Citation
Haltmar, H., Kolářová, B., Richards, J., Haltmar, M., Janura, M. Gait imagery in the context of postural stability.

Introduction

Motor imagery (i.e., even gait imagery) is a conscious mental simulation of movement without actually performing it [1]. Motor imagery training leads to improved movement execution, which is widely used in athletes but also in physiotherapy of neurological and orthopedic patients. Motor imagery is part of movement planning and preparation [1,2]. This can be objectified at a central level, especially by functional magnetic resonance imaging. What happens in the periphery during motor imagery is not so obvious, especially for complex movement such as gait. Therefore, the aim of our study was to investigate how postural stability changes when imagining normal gait and when imagining a more posturally demanding situation – gait on slackline.

Methods

Twenty-six young healthy probands with mean $\pm$ SD age, height and weight: 23.5 $\pm$ 1.69 years, 176.2 $\pm$ 9.08 cm and 68.5 $\pm$ 8.89 kg were included in the study. Inclusion criteria were achieving a good level of motor imagery (score $\geq$ 3 points) on the Movement Imagery Questionnaire-Revised and having no experience of gait on slackline. Immediate change in postural stability was sensed in bipedal standing using IMU Delsys Trigno sensors (Natick, MA, USA) from the pelvis, thighs and calves. Each subject completed in a randomized order the situation of imagining normal gait and imagining gait on slackline with their subphases (rest, imagining movement before and after performing the movement). Slackline on a self-supporting structure (Gibbon®) was used in the measurements. The mean 20 seconds of the gyroscope and accelerometer recordings were evaluated. Data were analyzed in Visual3D (C-Motion Inc., Germantown, MD, USA) using the remove mean and root mean square functions. Data were statistically evaluated by RM Anova with $p<0.05$.

Results

Significant changes in postural stability occurred only when imagining gait on slackline. At the pelvis, acceleration and angular velocity increased significantly in all three axes when comparing rest to imagining after performing the movement ($p<0.005$). Thus, imagining alone (imagining before performing the movement) does not lead to significant changes in postural stability. At the thighs and calves, no significant difference in postural stability was observed between dominant and non-dominant limbs. At the thighs, there is a significant increase in acceleration even when comparing rest to imagining alone, in the mediolateral direction (p=0.026). The angular velocity into external and internal rotation also increases (p=0.011). The same phenomenon in terms of accelerometric data occurs at calves (p=0.043), and the angular velocity increases in the abduction and adduction directions (p=0.031).

Conclusions

The results indicate that posturally less demanding movement (normal gait imagery) does not lead to statistically significant changes in postural stability. On the contrary, imagining gait on slackline leads to a significant increase in postural deviations corresponding to the deviations when performing the real movement. Thus, changes in postural stability were detected on lower limb segments more distal to the center of gravity during imaging alone. Accelerometers and gyroscopes are sensitive to detect changes in the periphery during imagined movement. The results support the fact that there is incomplete inhibition of the corticospinal tract during imagined movement.

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Age-dependent modulation of multisensory reweighting for controlling balance in a dynamic virtual environment

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Citation
Eikema, D.J., Papaxanthis, C., Hatzitaki, V. Age-dependent modulation of multisensory reweighting for controlling balance in a dynamic virtual environment.

Introduction
The ability to reweight visual and proprioceptive information is critical for maintaining balance in a dynamically changing environment [1]. Older adults require more time to reweight sensory information for maintaining balance while this critical period of instability could potentially increase incidence of falling in rapidly changing and cognitively demanding environments. In a series of three experiments, we manipulated visual and proprioceptive information during anticipation of a) avoiding collision with a virtual object,

b) intermittent galvanic vestibular stimulation (GVS) to investigate how young and older adults engage in sensory reweighting under static balancing conditions involving anticipation of an upcoming balance disrupting event.

Methods

In the first experiment, sixteen healthy old (age: 71.5±4.9 years; height: 159.3±6.6 cm; mass: 73.3±3.3 kg) and 20 young (age: 22.8±3.3 years; height: 174.4±10.7 cm; mass: 70.1±13.9 kg) participants stood for 240 s on a force platform under two experimental conditions: a) quiet standing, and b) standing while anticipating randomly approaching virtual objects to be avoided (Fig. 1). During both tasks, the visual surround changed every 60 s from a stationary virtual scene (room) to either a moving room or darkness and then back to a stationary scene to evoke visual reweighting processes. In the second experiment, twelve young (24.91± 6.44 years) and 12 older (74.8± 6.42 years) participants stood upright for 180 s under two task conditions: a) quiet standing, and b) standing while anticipating virtual objects to be avoided (Fig. 1). To disrupt the accuracy of proprioceptive input, participants were exposed to bilateral Achilles tendon vibration during the middle 60 s of standing in both tasks. In the third experiment, the participants of the second experiment stood upright under two task conditions: a) quiet standing, and b) standing while receiving pseudo-randomly presented bipolar 2 s GVS pulses. In both conditions, sensory reweighting was evoked by visual surround oscillations (20 cm, 0.3 Hz) and Achilles tendon vibration (3 mm, 80 Hz), concurrently delivered during the middle 60 s of standing.

Results

In quiet standing, older adults showed greater sway variability and were more severely affected by the removal or degradation of visual surround information compared to young participants. During visual anticipation however, both young and elderly participants were similarly affected by the degradation or removal of the visual surround. Young participants reduced the destabilizing effect of Achilles tendon vibration during visual anticipation of collision avoidance relative to quiet standing. For older participants however, the modulating influence of visual anticipation on postural sway

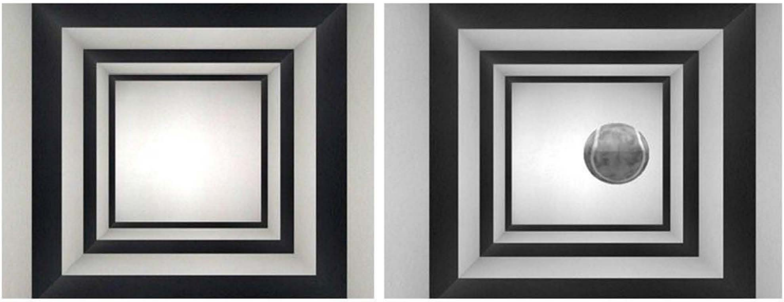

FIGURE 1
Illustration of the virtual room participants viewed via a head mounted display during a) quiet standing, and b) the collision avoidance task. In b) a virtual tennis ball moved at a constant speed towards the standing participant's face and the participant had to make a lateral trunk movement to avoid it.

variability induced by tendon vibration was delayed. Intermittent GVS decreased the excessive postural sway induced by the concurrent visual and proprioceptive perturbation in young but not in older participants.

Conclusions

The findings of the first experiment suggest that sensory reweighting in a dynamic virtual environment evoking visual anticipation interacts with postural state anxiety deteriorating visual reweighting regardless of age. Older adults show less efficient visual reweighting due to their greater visual field dependence [2]. The results of the second experiment suggest that volitionally shifting reliance on vision when anticipating a collision avoidance event facilitates the down-weighting of altered proprioception. Older adults however delay shifting reliance on vision to downweigh the altered proprioception possibly because of their more permanent up-weighting of the visual modality [3]. The results of the third experiment revealed that increasing reliance on the vestibular system facilitates the multisensory reweighting of standing balance. Older adults however are less able to exploit this stimulation to reduce the destabilizing effect of a multisensory perturbation [4]. Overall, sensory reweighting seems to be a more time consuming and cognitively demanding process in aging.

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Effects of different forms of noisy vestibular stimulation on standing balance

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Gavriilidou, A., Psillas, G., Konstandakos, V., Hatzitaki, V. Effects of different forms of noisy vestibular stimulation on standing balance.

Introduction

The vestibular system coordinates balance and body movement, providing information to the CNS [1] about head position, movement, and orientation in space [2]. Low levels of noise stimulation to the vestibular system (noisy vestibular stimulation, nVS) have been shown to improve stability during upright bipedal stance in healthy adults [3,4]. This enhancement is probably due to the phenomenon of stochastic resonance, according to which, adding random noise to a system can enhance the detection and transmission of weak signals [5]. However, there is still no consensus among scientists on the experimental protocols used to deliver the nVS, especially regarding the type of noise and the current intensity [6]. The purpose of the present investigation was twofold: 1) to examine the efficacy of an individual perceptual threshold detection method for identifying the appropriate intensity for nVS, and 2) to examine the effects of two forms of nVS, white and pink noise stimulation on standing balance of young healthy adults.

Methods

Forty-two healthy young participants (15 males, 27 females, age 30.0 $\pm$ 9.0 years) volunteered to participate in the study and were randomly divided into two groups: a group that received white noise stimulation (n=22), and a group that received pink noise stimulation (n=20). Participants were fitted with a set of bipolar electrodes, with the cathode electrode always attached on the left mastoid. Stimuli were generated by LABView, sent to an analog output device (NI PCI-6221, National Instruments, Austin, USA) and delivered to the participant after passing through an analog stimulus isolator (Model 2020, A-M Systems). Participants performed a threshold detection task followed by 8 trials of bipedal quiet standing. For the thresholding task, they received, while seated, 10 s bouts of nVS of increasing intensity in steps on 0.05 mA until they felt and verbally declared the stimulus onset and offset times for three successive stimuli bouts. This was defined as the individual perceptual (cutaneous) threshold intensity. For the standing task, participants stood for 60 s on a force platform (Bertec Balance Plate, 100 Hz) with feet together and eyes closed. nVS was applied during the second half of the trial (30 to 60 s) at 7 intensities around the individual perceptual threshold (50 %, 60 %, 70 %, 80 %, 90 %, 100 % and 110 % of threshold). A trial with sham stimulation was performed at the beginning of testing. Standing balance was quantified in the area, the root mean square (RMS) displacement and the mean velocity of the center of pressure (CoP). A normalized ratio (NR) of the stimulus vs. the no stimulus period was calculated for each balance measure and this ratio was then subject to statistical analysis.

Results

The mean threshold amplitude was not normally distributed across the two groups ($p<0.01$). Non-parametric Mann-Whitney comparison revealed that this was significantly higher for the pink (0.14$\pm$0.13 mA) than the white

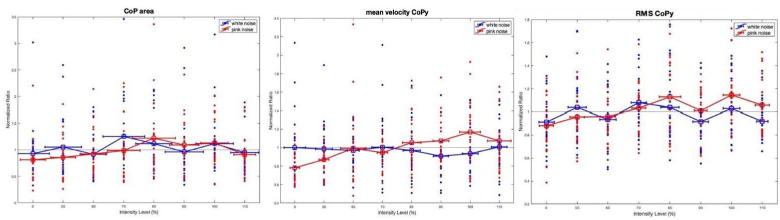

FIGURE 1
Normalized ratio (NR) of the stimulation vs. no stimulation period of quiet stance trial calculated for the CoP area (left), mean CoP velocity (middle) and RMS of CoP (right) in the mediolateral (y) axis, plotted across the 7 stimulus intensities (60 %, 70 %, 80 %, 90 %, 100 %, 110 % of perception threshold), and the sham (0) stimulation) for the white (blue) and the pink (red) noise groups. Figures show the group mean (in squares) and standard deviation (horizontal lines) along with individual data (dots).

(0.07±0.05 mA) noise group (U=62, p=0.024). The NR of the CoP area (Fig. 1, left) was not normally distributed across all stimulus intensities and therefore non-parametric comparisons revealed that this did not change across intensity levels for either of the two noise groups (white: $X^2_{(7)} = 9.09$, p=0.246, pink: $X^2_{(7)}=11.98$, p=0.101). The NR of the RMS of CoP (Fig. 1, right) in the mediolateral (y) direction increased significantly ($F_{(7,280)}=2.56$, p=0.014) at the threshold stimulation (100 %, p=0.004), 60 % (p=0.021) and 70 % (p=0.035) of threshold stimulation relative to the sham trial. No difference between the two noise groups was noted. The NR of the mean CoP velocity (Fig. 1, middle) was not normally distributed across all intensities ($p<0.05$). Non-parametric analysis revealed that this did not change across intensities for the white noise group ($X^2_{(7)}=3.27$, p=0.859). Nevertheless, this increased for the pink noise group ($X^2_{(7)}=32.71$, $p<0.001$) at 90 % ($p<0.001$) and 100 % ($p<0.001$) of threshold relative to sham stimulation.

Conclusions

The present findings suggest that nVS can influence standing balance, with higher intensity levels leading to increased body sway. Furthermore, the type of noise appears to play a role, with pink noise having a higher detection threshold and inducing a greater sway velocity relative to white noise stimulation. These results do not confirm a stabilizing effect of nVS in accordance with the stochastic resonance hypothesis [5] but contribute to the ongoing scientific discussion on optimal protocols for delivering nVS and further our understanding of the vestibular system's involvement in balance control.

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Importance of center of pressure measurements without force plate for balance assessment

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Citation
Hofstätter, O., Bochdansky, T.,Sabo, A., Bäckström, M. Importance of center of pressure measurements without force plate for balance assessmen.

Introduction

Numerous measurement methods have been established in the field of balance assessment. In addition to various clinical tests used to evaluate individuals' mobility and frailty, such as the Timed Up-and-Go test [1], Berg Balance Scale [2], Four Square Step Test [3], and newer variations like the timed 360° turn test [4], there are also several measurement systems that primarily rely on the center of pressure (COP) to measure different parameters [5]. Additionally, computerized posturography is used to quantify human balance ability, alongside manual tests and force plate measurements [6]. Furthermore, mobile devices such as the Tetrax Interactive Balance System (Sunlight Medical Ltd., Ramat Gan, Israel) have been developed. This system utilizes four mechanically separated force plates to measure the signals [7]. Its primary application is static posturography measurements.

Various comparative measurements have been conducted to assess the system's validity, demonstrating strong correlations and concurrent validity [8,9]. Given that force plates are commonly used for posturography, the need for separate systems for this purpose should be examined. Therefore, by utilizing an existing database recorded at a rehabilitation clinic in Schruns (Reha-Klinik Montafon Betriebs-GmbH, Schruns, Austria), this study aims to determine which posturography parameters are necessary for distinguishing between different classes. The hypothesis of this study posits that force plates may not be able to accurately interpret certain parameters due to their mechanical structure.

Methods

The available dataset comprises measurements taken from patients who underwent partial hip or knee endoprosthesis transplantation. The standard measurement procedure implemented in the Tetrax system was utilized in this study. The patient group consisted of 110 females and 81 males, with an average age of 67.9 $\pm$ 11.3 years. Additionally, the transplants were categorized based on their location (left or right side) and the type of prosthesis (knee or hip). To assess the feasibility of potential categorizations, the significance of various parameters was examined using different machine learning (ML) algorithms.

Results

During the data evaluation process, it was observed that patients who underwent partial knee arthroplasty exhibited clearer distinctions between each other compared to patients with partial hip arthroplasty. The analysis of feature importance provided valuable insights for interpretation and causal analysis. Notably, in several models, the center of gravity angle emerged as a highly significant parameter. Furthermore, it was discovered that the majority of the most important parameters were related to the assessment of weight distribution (WD). When the data was generalized into left and right classes, the accuracy of the classification further improved. The results are presented in Fig. 1, indicating that only 6 percent of cases were incorrectly categorized in the "right" class and 14 percent in the "left" class. Apart from achieving

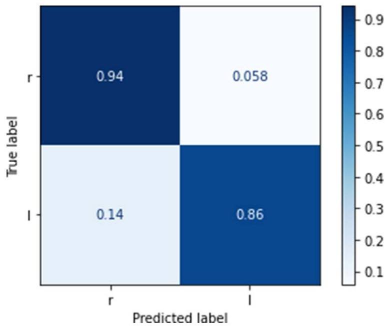

FIGURE 1

Confusion matrix for the evaluation of a machine learning model.

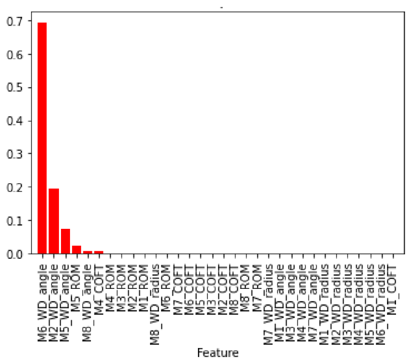

FIGURE 2

Feature importance from the trained model.

favorable results with simple models, the significance of the parameters is evident in Fig. 2. This visual representation highlights the decisive role of the angle in the classification process, with the WD angle of measurement 6 being the most influential parameter for the algorithm, followed by measurement 2 and measurement 5.

Conclusions

Given the system design of the Interactive Balance System, it is improbable to obtain an equivalent statement regarding this parameter using force plates. Therefore, it is crucial to not only perform COP measurements with standard force plates but also utilize specific systems like Tetrax for posturography assessments. The use of separate plates facilitates a reliable evaluation of WD parameter. ML models incorporating the four separate measuring platforms yielded successful results. The highest accuracy was achieved in side recognition. However, to achieve good results in classifying between hip and knee, additional parameters need to be employed. When using force plates, even with correct stance positioning, the errors in placement must be taken into account when evaluating the weight distribution. These findings can be valuable for automated detection of unloading postures or musculoskeletal system issues.

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How to decide the best balance and gait outcome measure for clinical trials

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Citation
Horak, F.B. How to decide the best balance and gait outcome measure for clinical trials.

Since wearable inertial sensors have made it feasible and useful to use quantitative balance and gait outcomes in multicenter clinical trials, it is important to consider how to select the best measure for each study. One of the challenges associated with quantitative assessment of balance and gait is the explosion of potential outcomes available, even from short performance tests. Clinical trialists need to identify the primary outcomes prior to initiation of the study but it is often difficult to determine which, specific, balance and/or gait measure should be chosen. Measures that are most sensitive to the particular disease and to the particular intervention are needed. However, redundant, highly correlated measures should be eliminated and potential benefits of representation from different domains of balance (APAs, APRs, Postural Sway, etc.) and different domains of gait (pace, rhythm, upper body, variability, stability) evaluated. The best measures as outcomes for clinical trials must also excel across many clinemetrics: verification of accuracy, clinical validity, sensitivity/specificity to disease and progression, effect size better than traditional clinical measures, meaningfulness to patients, etc.

However, no single digital measure of balance and gait is likely to be best across every clinematic evaluation. Thus, we propose use of the “Multiple Criteria Decision Analysis” (MCDA) approach as a systematic, transparent method to select the best potential outcomes for a clinical trial. This presentation will illustrate clinemetrics of balance and gait digital measures for several neurological diseases such as Parkinson’s disease and multiple sclerosis and demonstrate how MCDA can be used for developing a balance and gait composite score for spinocerebellar ataxia clinical trials.

Gait in different phases of the menstrual cycle

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Citation
Hrachovinová, S., Klein, T., Svoboda, Z. Gait in different phases of the menstrual cycle.

Introduction
The menstrual cycle (MC) influences women´s life in a significant way. Fluctuating levels of female sex hormones during MC cause regular changes in physical and psychological level of the body and thus participate in inconsistent performance of a woman in everyday life [1]. The effect of female sex hormones on some specific structures of locomotive system and association with risk of injury during sport has been described in the scientific literature [2]. It has been known, that higher estrogene levels during ovulation lead to higher laxity of connective tissues. Other study found higher laxity of plantar fascia during ovulation [3]. Maruyama et al. [4] discovered higher instability of the knee joint during ovulation. Women are also at higher risk of anterior cruciate ligament injury during ovulation [2]. It can result in changes in various movement tasks, however, the effect of different phases of MC on the performance of a comprehensive locomotive pattern, e.g., gait, has not been studied in detail yet. Gait as a basic movement behavior of a human reflects individual settings and changes at the level of locomotive system, internal organs, or psyche. We therefore assume, that also changes in levels of women sex hormones and their impact on neuromuscular system could influence gait pattern in different phases of the menstrual cycle. Thus, the

aim of the study was to investigate differences in gait performance and muscle activity between periovulatory and menstrual phase of MC in young healthy women.

Methods

The study population was 18 healthy young women (age 23.3 ± 1.7 years, height 169.0 ± 5.3 cm, weight 63.4± 6.8 kg a BMI 22.25 ± 2.5 kg/m^2). Inclusion criteria were regular and painless MC (≤3 points on Visual Analogue Scale). Exclusion criteria were especially use of hormonal contraception, gynecological disorder, present or previous pregnancy and illnesses requiring systemic treatment. All participants signed informed consent before starting the research. The research was approved by the faculty ethic committee. Firstly, we distributed online questionnaire to university students, and we enrolled study population meeting inclusion criteria. Secondly, all participants were instructed about the study protocol, and they obtained urine ovulatory tests (SeeNow LH, Nantong Egens Biotechnology Co., Ltd.) and instructions for their use. Thirdly, a series of measurements were performed at university gait laboratory. We followed the same protocol during periovulatory and menstrual phase of MC. The participants came to the laboratory within 72 hours from the beginning of menstruation or detection of positive ovulatory test. Ten gait trials were recorded for each participant. The movement of individual body segments was recorded by Vicon Vantage V5 motion capture system (Oxford Metrics, London, UK). Retroreflective markers were placed on the trunk, pelvis, and lower limbs using calibrated anatomical system technique. EMG electrodes (Trigno wireless system, Delsys Inc, Natick, MA, USA) were placed bilaterally on the area of erector spinae and lumbar multifidus muscles, meeting SENIAM recommendations for skin preparation. After data collection, the data was processed using Vicon Nexus 2.11 (Oxford Metrics Group, London, UK) and Visual 3D Professional (C-Motion Inc., Germantown, Maryland, USA). Finally, the data was statistically processed in Statistica v12 (TIBCO Software, Palo Alto, USA). The differences between periovulatory and menstrual phases of MC were assessed by paired t-test. P-value <0.05 was considered statistically significant.

Results

Our results showed greater pelvic, hip and ankle ROM during periovulatory phase of MC (Table 1).

TABLE 1: Results of kinematic analysis

ROM		**Menstruation**		**Ovulation**		**P-value**
	Plane	**Mean**	**SD**	**Mean**	**SD**	
Trunk	Sagittal	3.7	0.9	3.8	1.0	0.407
	Frontal	3.1	1.1	3.3	1.2	0.259
	Transverse	7.3	1.4	7.4	2.1	0.699
Pelvis	Sagittal	3.1	0.9	3.5	0.9	**0.026**
	Frontal	10.3	2.9	11.4	2.6	**0.003**
	Transverse	14.4	5.3	16.4	6.3	**0.000**
Hip	Sagittal	44.7	4.6	46.9	5.2	**0.032**
	Frontal	15.4	4.3	16.9	2.9	**0.009**
	Transverse	18.6	3.8	19.1	3.0	0.395
Knee	Sagittal	63.2	5.2	63.9	3.4	0.536
	Frontal	11.8	3.4	11.7	2.9	0.782
	Transverse	23.5	5.6	23.0	4.9	0.550
Ankle	Sagittal	26.5	4.2	28.9	3.4	**0.002**
	Frontal	13.6	2.5	15.0	3.0	**0.023**
	Transverse	9.8	2.5	11.4	3.7	0.090

ROM – range of motion; SD – standard deviation. ROM values are presented in angular degrees.

We also found significantly greater activity of the right erector spinae during menstruation (p=0.025) compared to periovulatory phase. For the activity of the left erector spinae and both lumbar multifidus muscles there was no significant difference between the phases.

Conclusions

Our results showed greater pelvic, hip and ankle mobility during ovulation compared to menstruation. We also found significantly higher activity of the right erector spinae. We can conclude that gait in young healthy women is affected by female sex hormones and ongoing phase of MC. The effect of MC on women's gait performance should therefore be considered in future research practice.

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Body size and the control of posture and movement

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Citation
Ivanenko, Y. Body size and the control of posture and movement.

Introduction
Terrestrial mammals come in a variety of sizes, with large and small creatures facing diverse mechanical and neural control challenges, which have an impact on the mechanisms underpinning postural and movement control [1]. In this presentation, the results of experimental studies on the mechanisms that stabilize the body will be addressed, and how these mechanisms may be affected by the effect of body size.

Methods
A cross-species study have been performed based on the available data in the literature on postural sway, center of pressure (CoP) oscillations, as well as the data related to the impairments in trunk control in humans in some forms of clinical pathology will be considered. A particular focus is placed on the comparison of animals of different size and a number of characteristics that distinguish bipedalism and quadrupedalism.

Results
Comparison of CoP oscillations showed that postural sway during standing is comparable in different animals (human, cat, dog, rat, flamingo, horse, elephant) despite the difference in the species considered with respect to size, morphology and phylogenetic relatedness [2,3]. Other considerations related

to the effect of body size, muscle force efficiency, and neurophysiological adaptations to specific gaits and posture in neurological disorders with motor deficits point to the relationship between the amount of body sway, neuromuscular limitations and the control of posture (muscle tone). It is worth noting that the disturbances in habitual posture in many forms of clinical pathology are related primarily to automatic rather than voluntary control of posture, consistent with two levels in the postural control system and specialized neural circuits for the control of posture and equilibrium [2, 4-6].

Conclusions

Identifying the effects of size on posture control through a cross-species study motivates further research into how the nervous system and biomechanics adapt to variations in body size across a wide range of species. The mechanisms underlying the control of habitual posture will be discussed, along with other considerations for how body size affects posture and movement control. Similar sway amplitudes across different species may suggest a shared multi-modal sensory threshold for posture control or shared neuromuscular constraints, and they indicate that not all aspects of sensorimotor postural control scale with size. These considerations are also important for the developmental studies and to whether and how the CoP amplitude should be normalized to the body height for the same child at different developmental ages.

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Automatically classifying gait from individuals with vestibular deficits using time-series data from wearable IMUs

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Jabri, S., Spicher, L., Carender, W., Wiens, J., Sienko, K.H. Automatically classifying gait from individuals with vestibular deficits using time-series data from wearable IMUs.

Introduction

Maintaining balance requires information from visual references, somatosensory signals, and vestibular inputs to navigate changing sensory environments [1]. Disorders affecting the vestibular system deprive individuals of essential sensory inputs to balance, increasing the risk of falls [2]. Identifying individuals with vestibular deficits through screening evaluations is important to inform referral to specialized testing, vestibular rehabilitation, and fall prevention interventions [3]. Gait assessments whereby trained clinicians observe and time walking under various sensory conditions [4,5] are commonly used to assess for gait deficits and identify individuals requiring further care. However, these assessments may not capture subtle changes or adaptations in movement and rely on visual examination by trained clinicians thus limiting their accessibility. Instrumented gait assessments utilizing wearable inertial measurement units (IMUs) and machine learning (ML) algorithms could support the accurate and automated identification of individuals with vestibular deficits. Prior approaches have investigated the automatic classification of gait from individuals with vestibular deficits using Random Forest (RF) models by extracting spatiotemporal gait parameters and relevant kinematic features from post-processed IMU signals [6]. Though these models achieved good performance (AUROC [95% CI] = 0.88 [0.84, 0.89]), they relied on features extracted based on prior knowledge of the tasks performed. Using engineered features can simplify the ML task by reducing the dimensionality of the input data. However, it also requires domain expertise to select features relevant to the classification task and may not capture all the nuances in the data. Using minimally pre-processed time-series data can be more computationally expensive and require more data, but can capture subtle differences beyond commonly measured gait metrics. The goal of this work was to assess the performance of deep-learning models trained on minimally pre-processed time-series IMU data to classify gait patterns from individuals with vestibular deficits and age-matched controls.

Methods

Thirty study participants (15 with vestibular deficits and 15 age-matched controls) performed seven gait tasks on a 6-meter walkway with an IMU placed on the left arm. Bi-directional LSTM (BiLSTM) models were trained on time-series data collected from each of the gait tasks. The dataset was randomly split following an 80/20 train/test split 50 times such that the data for six study participants at a time (three with vestibular deficits and three controls) were selected to be part of the testing set. Classification performance was reported in terms of average AUROC scores [95% confidence intervals] on the test set for each gait task.

Results

The BiLSTM models trained on minimally pre-processed time-series data generally achieved lower test AUROC performance compared to models trained on engineered features. Among the seven gait tasks, model performance varied significantly. Models trained on data from gait with eyes closed achieved the best classification performance AUROC [95% CI] = 0.83 [0.80,0.86] and 0.88 [0.84, 0.89], trained on time-series data and engineered gait features respectively.

Conclusions

Kinematic data from walking with eyes closed consistently enabled reliable classification of gait patterns from individuals with vestibular deficits and age-matched controls, regardless of pre-processing and learning approaches. Findings also highlighted that while BiLSTM models were able to learn discriminative patterns from the minimally pre-processed IMU data, feature engineering informed by task and domain knowledge may enable higher classification performance.

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Development of an automatic balance intensity evaluation system using wearable IMUs

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Introduction

Balance rehabilitation aims to improve an individual's ability to use available sensory information (i.e., reweighting of visual, vestibular, and neuromuscular inputs) and reduce fall risk [1]. The effectiveness of balance training depends on dosage [2] which follows the FITT principle [3], i.e., the "Frequency", "Intensity", "Time" and "Type" of exercises prescribed. In particular appropriate exercise intensity, whereby "exercise must be performed near an individual's capacity" [4] is needed to induce a training effect. In clinical rehabilitation settings, balance intensity is usually assessed by supervising physical therapists (PTs) through observations and standardized assessments to inform appropriate exercise assignments. However, access to balance training sessions supervised by PTs is limited by factors relating to patient load [5], insurance [6], travel [7] thus making home-based training an important component of balance rehabilitation. The effectiveness of home-based balance training is, however, negatively affected by the lack of supervision from PTs [2]. The goal of this study was to develop wearable sensor-based automatic assessment tools to facilitate the evaluation of balance task intensity in the context of balance training for individuals with balance conditions.

Methods

Forty-seven exercise participants (age 51 $\pm$ 18y; 30 female, 17 male) including healthy adults and individuals with balance-related disorders participated in a single-session study. Exercise participants wore a full-body (13) set of wearable inertial measurement units IMUs to capture kinematic measures of their movements during balance training. Exercise participants were filmed performing up to 4 exercises (with three repetitions for each exercise) that included standing on firm and compliant surfaces under varying sensory conditions. Forty-four PT study participants participated in a survey-based study. Respondents were PTs licensed to practice in the US with experience in balance rehabilitation. PT participants were asked to watch videos of up to five randomly selected exercise participants performing balance exercises, provide balance intensity ratings on a 1-5 scale, and reflect on their rationales for providing ratings following a think-aloud protocol. A dataset of time-series kinematic measures (accelerations and angular rates) and their corresponding balance intensity ratings provided by PTs was used to train 2-D convolutional neural networks (CNN) to predict balance intensity ratings for each task. Model training and validation were performed for different combinations of IMU placements following a 5-fold cross-validation process at the level of study participants to assess model generalizability across different participants. Model performance was assessed using root mean square errors (RMSE) to capture the discrepancies between predicted ratings and actual PT ratings.

Results

Models were able to predict PT ratings with RMSEs ranging from 0.71 to 0.78 across all IMU placements. IMUs placed on the left thigh (RMSE [95% CI] = 0.710 [0.707, 0.714]), right arm (RMSE [95% CI] = 0.720 [0.712, 0.729]), left wrist (RMSE [95% CI] = 0.729 [0.722, 0.735]), and lumbar segment (RMSE [95% CI] = 0.730 [0.729, 0.732]) resulted in the highest performance.

Conclusions

ML models trained on kinematic data from wearable IMUs were able to predict PT ratings of balance task intensity within 1 rating on a 1-5 scale. These findings could support the development of automatic balance assessment systems to monitor balance intensity levels throughout balance rehabilitation programs to ensure appropriate and effective challenge in training.

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Non-linear approach for assessment of gait and stance in elderly individuals – A 5-year follow-up study

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Introduction
It is widely known that balance and gait performance declines during the process of aging. This decline is demonstrated as a loss of stability and increase of variability of the movement performance [1]. Non-linear approaches for data analysis showed a relevance to age when comparing several age-groups and studying maturation of gait and balance [2-4]. However, the interpretation of obtained results is often unclear. A longitudinal observation of changes of non-linear measures related to aging of elderly individuals could provide more understanding of these measures. Therefore, the aim of this study was to compare the stance and gait performance of the same group of elderly participants within a time interval of 5 years.

Methods

23 active healthy elderly aged over 65 years participated in the study. Based on the Tinetti Performance Oriented Mobility Assessment, they were considered at low fall risk during both testing sessions – baseline and 5 years later during a follow-up. The same testing protocol was employed for both testing sessions. Participants' gait and postural stability during stance were assessed by linear and non-linear approaches. Gait was performed in the indoor well-lit corridor at the preferred walking speed for a time period of 5 minutes with an inertial sensor attached to the lower back. 150 gait cycles were analyzed – gait speed, variability, local dynamic stability and sample entropy were computed from linear acceleration in vertical (V), medial-lateral (ML) and anterior-posterior (AP) directions. Postural stability during stance was assessed during 4 conditions with feet hip-width apart – firm surface with eyes open (EO) and closed (EC), soft surface with eyes open (SEO) and closed (SEC). Centre of pressure movement velocity and sample entropy were analyzed. To assess the longitudinal changes in performance, data obtained in both testing sessions were compared by a Wilcoxon test.

Results

For gait, the results did not show significant change in the participants' walking speed. An increase of stability and complexity was found in V direction. On the other hand, a decrease of stability and complexity and increase of variability was observed in AP direction (Table 1). Interesting results were found for stance. Most of the significant changes were found in conditions with eyes open. Results showed that velocity and complexity increased in the follow-up testing compared to the baseline measurement (Table 2).

TABLE 1: Gait performance results

		Baseline			Follow-up			
Variable	**Direction**	**Median**	**Lower Quartile**	**Upper Quartile**	**Median**	**Lower Quartile**	**Upper Quartile**	**P-value**
Local dynamic stability	V	0.98	0.87	1.09	0.91	0.75	0.99	0.016
	ML	1.19	1.05	1.26	1.11	1.02	1.27	0.903
	AP	0.93	0.86	1.03	1.08	0.87	1.17	0.039
Variability	V	0.24	0.21	0.27	0.21	0.19	0.26	0.048
	ML	0.14	0.13	0.16	0.16	0.13	0.17	0.693
	AP	0.15	0.13	0.18	0.32	0.17	0.39	< 0.001
Entropy	V	0.47	0.41	0.57	0.53	0.47	0.62	0.016
	ML	0.72	0.63	0.77	0.75	0.66	0.84	0.057
	AP	0.56	0.50	0.65	0.42	0.35	0.58	0.001

Note. AP – anterior-posterior, ML – medial-lateral, V – vertical

TABLE 2: Stance performance results

		Baseline			Follow-up			
	Variable	**Median**	**Lower Quartile**	**Upper Quartile**	**Median**	**Lower Quartile**	**Upper Quartile**	**P-value**
EO	Velocity ML	3.45	2.87	4.34	3.85	3.05	4.94	0.007
	Velocity AP	7.63	6.10	9.82	10.59	8.69	13.77	< 0.001
	Entropy ML	0.10	0.09	0.14	0.12	0.09	0.18	0.011
	Entropy AP	0.07	0.05	0.08	0.07	0.06	0.09	0.116
EC	Velocity ML	4.51	3.57	5.52	3.96	3.40	5.14	0.022
	Velocity AP	10.67	8.84	13.98	12.26	9.43	16.92	0.086
	Entropy ML	0.12	0.09	0.14	0.11	0.11	0.17	0.162
	Entropy AP	0.07	0.06	0.09	0.07	0.06	0.09	0.886
SEO	Velocity ML	8.50	6.96	9.85	10.40	8.52	15.01	< 0.001
	Velocity AP	16.31	13.17	18.80	26.13	19.49	31.98	< 0.001
	Entropy ML	0.05	0.04	0.06	0.06	0.05	0.07	0.006
	Entropy AP	0.07	0.06	0.08	0.07	0.06	0.09	0.004
SEC	Velocity ML	15.66	12.06	20.48	12.94	10.75	17.81	0.248
	Velocity AP	32.23	27.26	40.85	36.30	27.15	38.84	0.128
	Entropy ML	0.06	0.05	0.07	0.06	0.05	0.07	0.951
	Entropy AP	0.07	0.06	0.09	0.08	0.06	0.10	0.030

Note. AP – anterior-posterior, EC – firm surface with eyes closed, EO – firm surface with eyes open, ML – medial-lateral, SEC – soft surface with eyes closed, SEO – soft surface with eyes open

Conclusions

The result showed stiffer gait pattern in V direction of movement explainable by physiological changes of the body caused by aging. As suggested by [1], changes of complexity are dependent on the studied task. While decrease was observed in AP direction of gait, statistically significant increase (although only slight change of absolute values was shown) was observed in all cases during stance, together with an increase of velocity of postural titubations. Interestingly, during eyes closed conditions, only a few changes were observed indicating that the decline of stability is manifested in more common conditions (e.g., while performing a task with EO).

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Movement analysis of paretic lower limb using surface electromyography: A case study

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Jasenská, M., Horníček, J., Olšák, P., Kolářová, B. Movement analysis of paretic lower limb using surface electromyography: A case study.

Introduction

Movement performance of a healthy organism is characterized by a high degree of variability in the execution of the movement task. In situations caused by disorders of movement, mainly as a result of neurological or traumatological lesions, the ability to perform movement is limited to varying degrees. The aim of this case study was to assess the effect of electrostimulation of denervated muscle (tibialis anterior) by surface electromyography.

Electrostimulation slows down denervation-induced atrophy and extends the time window available for successful axon reinnervation [1].

Methods
Man (58 years old) with paresis of the nervus ischiadicus with major damage to the nervus peroneus communis, clinically manifested by motor loss of the dorsiflexors and evertors of the foot, was assessed in this case study. He was asked to perform dorsiflexion, walking along a corridor and walking on a treadmill. These movements were performed before and after electrostimulation (combination of classical electrostimulation with acupuncture). During all tested movements, foot angular velocity data was recorded using an Inertial Measurement Unit sensor (Delsys, Inc.). Simultaneously, muscle activity from tibialis anterior and gastrocnemius medialis was measured using sEMG (Delsys, Inc.). The EMG signals were processed by mean removal, a 20 Hz high-pass filter and a 500 Hz low-pass filter, root mean square (RMS) [2]. The mean, minimal and maximal values of the angular velocity and sEMG data were calculated before and after electrostimulation.

Results
The recording of angular velocity over time demonstrates a clear time course of all tested movements after electrostimulation. These changes were accompanied by markedly increased recruitment of muscle activity in the EMG signal, especially in the tibialis anterior muscle. During walking, the time course of the bounce was faster both in the corridor and on the treadmill.

Conclusions
Active motion assessment, including a comparison of the signal waveforms from gyroscopic and electromyographic sensors, demonstrated an improvement in movement execution after electrostimulation. This data would support the hypothesis that electrostimulation facilitates active motion execution, however, the longer-term assessments in a larger cohort of peripheral paresis patients are required to confirm these findings.

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Reinforcement and error feedback differentially impact motor exploration during gait

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Citation
Jeka, J., Gray, J., Roth, A., Buggeln, J., Reimann, H., Cashaback, J.G.A. Reinforcement and error feedback differentially impact motor exploration during gait.

Introduction

Error-based feedback is typically thought to play the dominant role in learning a new movement pattern. However, recent work has underscored how reinforcement feedback may play a critical role as well [1]. Reinforcement provides binary (success/fail) feedback to the subject while error feedback relays vectored (magnitude and direction) error relative to a target. Previous studies in reaching have shown that participants actively inject additional variability to find the optimal solution to a motor task [2,3]. During reaching we have recently shown that a lack of reinforcement (failure) causes greater variability and positive reinforcement (success) updates the intended motor action towards the last success, leading to greater spatial exploration of the solution space [4]. Here we investigated the roles and interplay of reinforcement and error feedback on motor exploration while walking.

Methods

Six healthy young subjects (age 22-26, 3M) were recruited for this study. Subjects walked on a Bertex instrumented treadmill with a 180° virtual reality screen showing an endless path of randomly generated cubes that flowed past as the subject walked on the treadmill. After an acclimation period to the self-paced treadmill and virtual reality environment, subjects went through a step mapping trial where they were encouraged to adjust their step length according to real-time feedback provided on the visual screen (Fig. 1). For the experimental conditions, subjects were given a target step length created from their baseline left step length plus 2 standard deviations with a width of ± 1 standard deviation. Subjects completed the 5 min blocks of feedback conditions (preceded by 1 min of ramp up and followed up 1 min

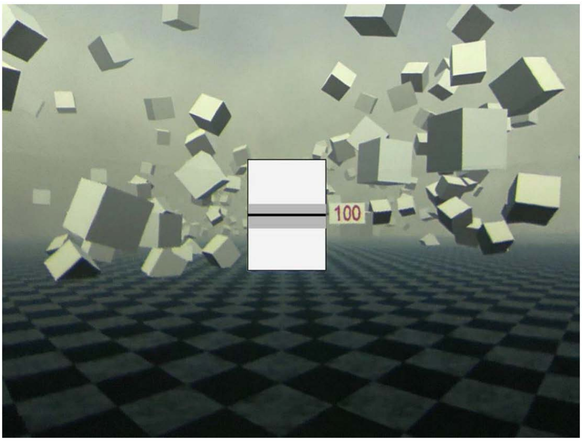

FIGURE 1
Example of the error feedback condition provided to the subjects during the task. Counter box was placed adjacent to the feedback screen and enumerated the amount of cumulative target hits.

of wash-out) in a counterbalanced order. In the error feedback block, we provided vectored error feedback by displaying their left foot step length as a horizontal line relative to a target left foot step length. In the reinforcement feedback block, the gray target would turn blue and they received a small monetary reward when their left foot step length was within the target bound. We also displayed the cumulative number of target hits. Subjects did not have knowledge of the magnitude of their error for the reinforcement block, only whether they hit the target or not. In the combined condition they were shown both types of feedback simultaneously. A custom MATLAB script collected step length and width values for both feet on each step throughout the feedback blocks. The ramp up and wash out conditions displayed no feedback.

Results

Left step length was compared to the target step length on each step. Lag-1 autocorrelations of the step length were calculated for each feedback

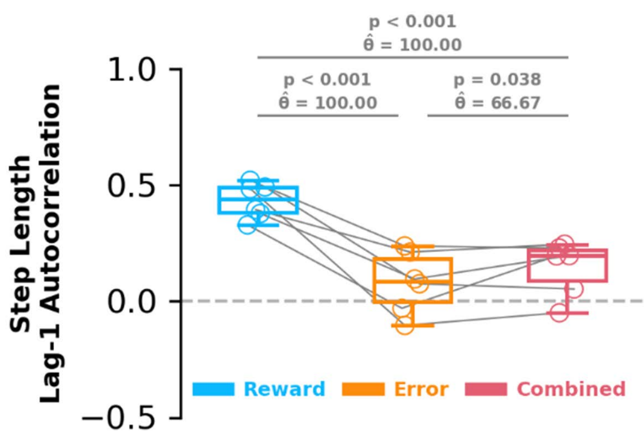

FIGURE 2

Step length lag-1 autocorrelation for each of the three feedback conditions. Dots represent the average value for each subject.

condition (Fig. 2). A greater lag-1 autocorrelation represents a greater level of step length exploratory behavior during the walking task [4]. A bootstrapped hypothesis test on the paired differences showed that the reinforcement feedback led to greater motor exploration during walking (i.e., a higher lag-1 autocorrelation).

Conclusions

Preliminary results from our step length modulation paradigm provide promising evidence that exploration is a generalizable mechanism across reaching and gait, which can be used to adapt and potentially learn new movement patterns. Further study will help to understand the ways in which the upper and lower limbs may differ as well as investigating the neuroanatomical input to motor adaptation with basal ganglia impairments due to Parkinson's disease [5].

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New possibilities of trunk symmetry modulation in stroke patients using combined sensory stimulation

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Introduction

Stroke is the second leading cause of death and a major cause of disability worldwide. Its incidence is increasing because the population ages. In addition, more young people are affected by stroke nowadays [1]. The main deficit caused by stroke is motor impairment in terms of loss or limitation of muscle control function or movement, or limitation in mobility [2]. Marked temporal and spatial inter-limb asymmetries are also common [3]. Posture and mobility problems in those patients are worsened by impaired integration of sensory signals required to construct body representation, maintain a stable posture and safely move in space [4]. Mounting evidence encourages efforts to modulate symmetry of sitting or stance through targeted intervention protocols. Among others, the visually guided voluntary weight shifting toward visual targets while receiving the center of pressure (CoP) feedback seems to be promising as it may strengthen the sensory integration within postural control [5] and simultaneously induce a more active role of the paretic side in stroke patients [6]. Moreover, appropriate somatosensory stimulation (e.g., vibration) suggest the possibility to recalibrate the internal model of verticality and to improve body orientation in space [7]. Therefore, we aim to use visual biofeedback stimulation along with vibratory stimulation of trunk muscles to modulate trunk symmetry during sitting and standing in stroke patients.

Methods

Stroke patients will be recruited from University Hospital Bratislava. The patient will undergo a consultation with a physical medicine & rehabilitation medical doctor who will validate the patient´s participation according to the inclusion/exclusion criteria and will be responsible for supervision of all measurements and training protocol. Before the training, the patient will be initially assessed to get baseline postural parameters. After 10 days of personalized training, the same postural parameters will be obtained for comparison to baseline. The postural sway will be measured during sitting by force platform inbuilt in special modular seat originally developed within the project APVV-16-0233 using the original software. Postural control will be evaluated by CoP variables as amplitude and velocity of CoP displacement, path length, sway area, root mean square, mean frequency etc. Trunk tilts will be also recorded by inertial sensors. The baseline postural assessment will include sitting on firm/foam support surface with eyes open or closed, testing the functional limits of stability in frontal and sagittal planes and evaluation of postural responses to visual, somatosensory and combined sensory stimulations. The training intervention will be composed of different postural tasks including the visually guided voluntary weight shifting toward visual targets based on CoP signal feedback alone, and in combination with the unilateral vibration of *m. quadratus lumborum*.

Conclusions

Many of stroke sufferers remain disabled in basic activities of daily living and have reduced mobility due to hemiparesis. Such essential acts as rising from a chair or grasping the items are challenging for them. Visually guided repetitions of trunk tilts as well as longer lasting lateral trunk tilts may significantly contribute to restoring the trunk movement symmetry in stroke patients. We believe that intervention with personalized postural tasks based on voluntary weight shifting using visual biofeedback along with unvoluntary trunk tilts induced by trunk muscle vibration will help to extend the limits of stability, facilitate multisensory integration for restoring postural symmetry and overall improve balance control post-stroke.

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Influence of backpack loading on the static postural equilibrium of primary school children of different ages

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Kirilova, K., Yordanova, Y., Ivanov, D., Stambolieva, K. Influence of backpack loading on the static postural equilibrium of primary school children of different ages.

Introduction

In recent years, a number of studies have found a link between weight of school backpacks and the damage that their excessive load causes. Carrying a heavy backpack daily in the long run leads to distortions of the spine relative to its axis. To compensate for the weight, the body reacts with a change in posture, which in many cases results in slouching and shifting the center of gravity forward, in order to compensate for the weight. As a result, an unnatural compression of the spine takes place, which leads to distortions, imbalances, various types of neck and shoulder injuries, back pain, etc. [1]. A study from 2015 defines as the maximum acceptable loading of the student backpack - up to 10 % of the child's body weight [2]. However, very often this recommendation is disregarded and the backpacks of children, even in primary school, exceed 15-20 % and further research is required to evaluate the physiological effects of backpack loading [3]. The aim of this study is to evaluate the effects of 15-20 % backpack loading on the static postural equilibrium in children of different grades in primary school.

Methods

Thirty-nine healthy primary school children were investigated, divided in two groups: 23 younger children (7 years old) and 16 older ones (9-10 years old). Postural stability was measured with a posturographic system in two conditions: standing with eyes open with a backpack loaded 15-20 % of child's weight, placed on both shoulders and close to the back and the same condition without a bag. Evaluated measures: mean amplitudes of postural sway in the anterior-posterior (AP) and medio-lateral (ML) directions.

Results

The postural sway amplitudes in the AP and ML directions were similar in the two age groups with higher amplitudes of sway in the AP direction. Standing with a 15-20 % loaded backpack increased the postural sway in both age groups but in different ways. When loaded, the 9-10-year-olds maintain the balance pattern by increasing their sway in both directions, especially in the AP direction. In contrast, the younger children changed the pattern of maintaining standing equilibrium – their mean ML amplitudes of postural sway significantly increased with loading while in the AP direction no significant changes were observed.

Conclusions

The results suggest that standing with a 15-20 % loaded backpack on both shoulders, regardless of preserving the symmetry of the body, has destabilizing effects on postural stability in static upright standing, most prominently in the 7-year-olds. The observed different pattern of maintaining equilibrium with loading in the younger children with increasing lateral sway is likely due to the fact that their musculature is weaker and the vestibular system is developing, whereas in the 9-10 years old children the effects of the load are added to the momentum of the body.

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Gait and motor recovery in acute ischemic stroke patients after early intensive rehabilitation

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Introduction

Walking is one of the most important activities of daily living and restoring gait independency has become a critical goal of post-stroke neurorehabilitation. Task-specific training and repetitive exercise are key elements of training to enhance motor recovery post-stroke by experience- and learning-dependent neuroplastic processes [1,2]. The aim of this study was to assess a gait and a motor recovery after intensive rehabilitation in early subacute phase in first ever stroke patients.

Methods

Consecutive patients with ischemic stroke in anterior circulation were participating in this study. All patients were included in the pilot analysis of GAITFAIST trial (NCT04824482) [3] and had impaired gait as consequence of ischemic stroke. Patients were divided into the group of dependent walkers (DW, categorized according to FAC <1;3>) and the group of independent walkers (IW, categorized according to FAC=4). In the group of DW were enrolled 16 participants (72±8.4 years) with median FAC score 3 (1-3). In the group of IW were enrolled 11 participants (62±9 years) with FAC score 4. Rehabilitation started in both groups 12±5 days after stroke onset and lasted for 14±5 days. The study was realized at Rehabilitation Department, where all participating patients were admitted for intensive rehabilitation program including individual physiotherapy with add-on assisted or non-assisted gait training. The type of gait training was chosen with respect to participants´ functional level of gait independency according to Functional Ambulatory Category (FAC). Gait recovery was in both groups evaluated using the FAC and 10-meters walking test (10MWT). Motor recovery was evaluated using Fugl Meyer Assessment for Lower limb (FMA-LE). All tests were performed before and after intensive rehabilitation. Nonparametric tests were used to compare outcomes between DW and IW, and to compare outcomes for both groups before and after rehabilitation ($p \leq 0.05$).

Results

The DW walked before rehabilitation at slower speed (0.75±0.28 m/s) in comparison to IW (0.95±0.23 m/s; $p \leq 0.05$). After rehabilitation the difference for DW (0.89±0.28 m/s) did not significantly differ to IW (1.14±0.305 m/s). The IW group did not improve in gait speed significantly after rehabilitation instead of DW. Motor function according to FMA-LE was lower in DW both before (score 23±5) and after (score 26±4) rehabilitation ($p \leq 0.05$) in comparison to IW who perform better on FMA-LE before (score 28±3) and after rehabilitation (score 30±2). Both groups improved for FMA-LE motor domain before and after rehabilitation ($p \leq 0.05$). No differences were found between both groups for sensation domain in FMA-LE.

Conclusions

DW after ischemic stroke have great potential to become independent in walking and increase their walking speed after intensive rehabilitation program in early sub-acute stage post-stroke. The early subacute period offers an optimal therapeutic time window for achieving maximal therapeutic effect of neurorehabilitation. Especially starting during the acute stages after stroke, repetitive, high dose, task specific training enhances neuroplasticity and may accelerate gait recovery after stroke [4,5].

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Fall prevention in slovakia: What can be done?

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Košutzká, Z., Martinkovičová, A., Janovič, Š., Šaling, M., Valkovič, P. Fall prevention in slovakia: What can be done?

Falls can have a significant impact on an individual's health and well-being with increasing prevalence in the ageing population. Slovakia is a country with one of the highest incidences of falls worldwide [1]. No prevention strategy has been systematically applied so far. Nevertheless, by implementing effective practices and making necessary modifications, individuals can significantly reduce their risk of falling and maintain their independence and quality of life. On the other hand, the results of the meta-analysis show that despite the high effectiveness of multifactorial interventions to prevent elderly falls, the cost of the interventions is high and they are not very cost-effective [2]. National fall prevention strategies may differ in scope and implementation across countries, reflecting variations in healthcare systems, population demographics, and cultural factors. We aim to present the available data on fall epidemiology in Slovakia. The secondary aim is to present a multifactorial intervention framework with low cost and high effectiveness that would be feasible in the current state of healthcare in Slovakia. The main focus will be on the elderly population.

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Robotol vs surgeon: Comparison of vestibulospinal outcomes in patients with robot or surgeon inserted electrode array during the cochlear implantation

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Introduction

Hearing loss is a condition that significantly affects the quality of life. It is also connected with a high risk of falling and reduction of cognitive functions [1,2]. The prevalence of this disability is relatively high due to many conditions which may result in deafness. In 2030 the WHO predicts the grove of the number to 630 million people with hearing impairment [3-5]. Cochlear implant (CI) is the most effective neural prostheses worldwide. For sensorineural hearing loss patients, the CI is a standard tool to regain their hearing ability. The inner part of the implant consists of an electrode array that produces an electric current when it is exposed to an electromagnetic field. There can be more than 20 electrode channels in today's implants. Each electrode ends at a different place in the cochlea and delivers the signal to the spiral ganglion neurons [6,7]. The procedure is considered common and safe with low postoperative complications for adults and also for pediatric patients [8,9]. But the results of cochlear implantation and the success of the patient's rehabilitation after the surgery highly depend on several pre-operative (state of the structure of the inner ear) and peri-operative factors. There is a possibility to damage the cochlea of the inner ear by the insertion of the electrode bundle. The bundle must be located in the tip of the tympanum close to the spiral ganglion, for the best possible transmission of the electrical signal. Robot-assisted cochlear implantation aims to perform minimally invasive access through a small tunnel to the inner ear for electrode array insertion. Several systems for robot-assisted cochlear implantation have been developed already and are available on the market these days [10]. Current clinical trials are generally focused on accurate stapes surgery, minimally invasive access to the cochlea and less traumatic insertion of cochlear implant electrode arrays [11]. Our multidisciplinary study group has been collecting data from patients who underwent cochlear implantation since 2019 and it has been more than 30 years since the first implantation in the Czech Republic. Last year we had a unique opportunity, as the first ENT department in Central and Eastern Europe, to use the robotic system for the insertion of the electrode array. The use of the RobOtol® (Collin, Bagneux, France) provides very accurate and slow insertion of the electrode array. It is supposed to eliminate the surgeon's hand tremor and thanks to it reduce the possibility of damage on the surrounding structures [12]. The postoperative complications are often associated with the histopathology changes of the structures in the inner ear. These occurred during the surgery and can cause impairment in the vestibular functions [13,14]. We assumed that if we provide gentler option for the surgical insertion to the patient's ear, we can expect better postoperative outcomes. This study aims to evaluate the vestibulospinal functions in patients after the CI and compare the results between two groups – the group of patients operated by the robotic arm and the group that was operated by the hand of the surgeon.

Methods

In total 37 (24 female, mean age±SD was 42.9±13.0) candidates for CI underwent an assessment in the stabilometric laboratory. In 14 cases the insertion of the electrode array was performed by a robotic system and 23 were operated conventionally. In all of these patients, we also performed the same examination the first day after the surgery and 34 came for the following examination in 3 weeks after. The protocol consists of static posturography in ten conditions, perception of subjective visual vertical (SVV) in dynamic and static mode and answering a Dizziness Handicap Inventory (DHI) questionnaire.

Results

There was no difference between groups in the perception of SVV, patients in both groups were statistically significantly affected by the surgical procedure (SVV deviation in direction toward implanted ear: 0.90°±1.25, -1.67°±3.05 and -0.19°±1.78 before and after surgery ($p<0.001$) and in 3 weeks ($p<0.01$), respectively). In postural parameters, we did not find a significant difference between the groups not even in the time. Subjective assessment was nearly the same in both groups.

Conclusions

The robotic-assisted insertion of the electrode array during CI does not lead to better results in vestibular outcomes in the short-term sequence after the procedure.

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Subjective visual vertical and head position in patients with idiopathic scoliosis

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Introduction

Idiopathic scoliosis (IS) is a structural spinal deformity that can affect the position of the head [1,2]. One of the etiological hypotheses is that it can be caused by dysfunction of the vestibular system, which can cause abnormal perception of subjective visual vertical (SVV) [3-6]. This study aimed to evaluate the differences in head position and its possible correlation with the perception of SVV in children with IS.

Methods

We examined 37 patients with IS and 37 healthy individuals. The position of the head was evaluated from digital photographs, where we compared the coronal head tilt and the coronal shoulder angle. Measurement of SVV perception was performed using the Bucket method.

Results

Coronal head tilt values were significantly different between the groups (median 2.3° [interquartile range 1.8-4.2] vs 1.3° [0.9-2.3], $p=0.001$; patients vs. controls, Fig. 1). There was a significant difference in SVV between the groups (2.33° [1.40-3.25] vs 0.50° [0.41-1.10], $p<0.001$; patients vs controls, Fig. 2). There was a correlation between the side of head tilt and the side of SVV in patients with IS ($\chi^2=5.6$, $p=0.02$).

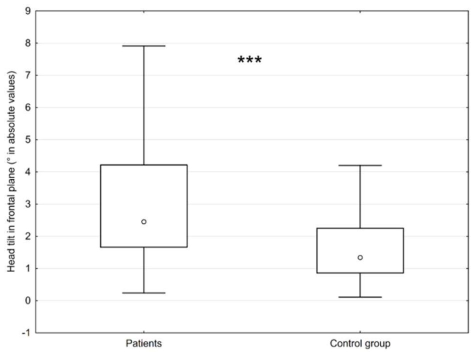

FIGURE 1

Head tilt in patients with idiopathic scoliosis vs healthy controls (median, midrange and min-max range).

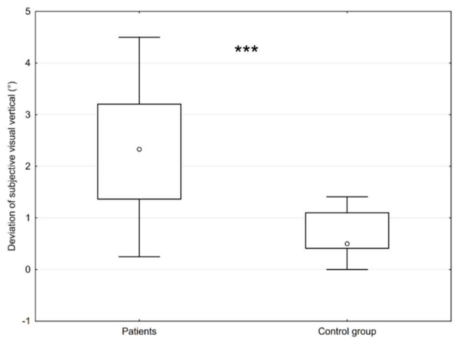

FIGURE 2

Deviation of subjective visual vertical in patients with idiopathic scoliosis vs healthy controls (median, midrange and min-max range).

Conclusions

Our study is the first to associate head position and SVV perception in patients with IS. Our findings show a greater head tilt and a greater deviation of SVV in a similar direction in patients with IS.

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Random field theory for testing differences between frequency response functions in posturography

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Lippi, V. Random field theory for testing differences between frequency response functions in posturography.

Introduction

The frequency response function (FRF) is an established way to describe the outcome of experiments in posture control literature. Specifically, the FRF is an empirical transfer function between an input stimulus and the induced body movement. By definition, the FRF is a complex function of frequency. When statistical analysis is performed to assess differences between groups of FRFs (e.g., obtained under different conditions or from a group of patients and a control group), the FRF's structure should be considered. Usually, the statistics are performed defined a scalar variable to be studied, such as the norm of the difference between FRFs, or considering the components independently (that can be applied to real and complex components separately [1,2]), in some cases both approaches are integrated, e.g., the comparison frequency-by-frequency is used as a post hoc test when the null hypothesis is rejected on the scalar value [3]. The two components of the complex values can be tested with multivariate methods such as Hotelling's T2 as done in [4] on the averages of the FRF over all the frequencies, where a further post hoc test is performed applying bootstrap on magnitude and phase separately. The problem with the definition of a scalar variable as the norm of the differences or the difference of the averages in the previous examples is that it introduces an arbitrary metric that, although reasonable, has no substantial connection with the experiment unless the scalar value is assumed a priori as the object of the study as in [5] where a human-likeness score for humanoid robots is defined on the basis of FRFs difference. On the other hand, testing frequencies (and components) separately does not consider that the FRF's values are not independent, and applying corrections for multiple comparisons, e.g., Bonferroni can result in a too conservative approach destroying the power of the experiment. In order to properly consider the nature of the FRF, a method based on random field theory inspired by [6] is presented in the next section. A case study with data from posture control experiments [2] is presented. To take into account the two components (imaginary and real) as two independent variables, the fact that the same subject repeated the test in the two conditions, a 1-D implementation of the Hotelling's T^2 is used as presented in [7] but applied in the frequency domain instead of the time domain.

Methods

Case study with an example of results - consider the body sway induced by a movement of the support surface, where the support surface was tilted with a pseudorandom profile (PRTS, see [8] for the original formulation and [2] for a shorter version of the signal). It should be noted that the FRF can be obtained with other stimulus modalities (e.g., translation [1,3,9]) or input profiles (e.g., step or raised cosine). In the example shown in Fig. 1, the responses are compared (left and center). The Hotelling's T^2 is shown (on the right), confirming the expected result that vision makes a significant difference in the response [1,9,10]. With the 1-D statistics, the difference is localized in frequency without requiring to define specific ranges of frequencies [9] or testing the single sample points independently [1,3].

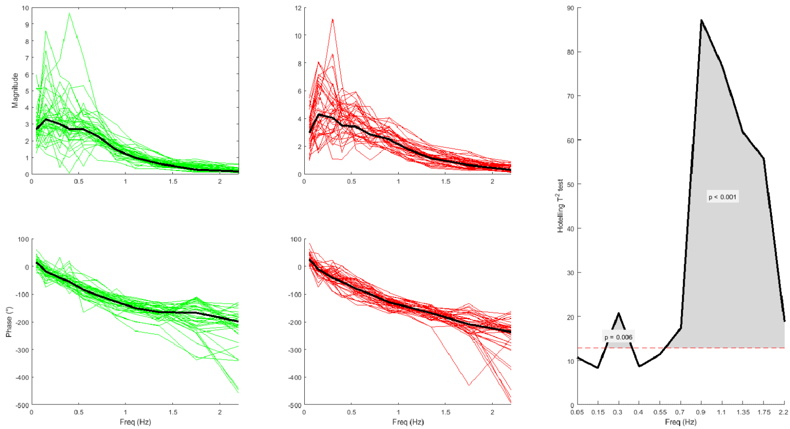

FIGURE 1

Example of sets of FRFs and a one-dimensional statistical test. FRFs are plotted for body sway response to 1° peak-to peak PRTS support surface tilt. In green, the eyes open condition responses are on the left. In red are the responses for eyes closed in the middle. For each condition, the same 32 subjects are tested. Data are from [2]. On the right is the result of a paired Hotelling's T^2 test performed on the continuum with [6]. The threshold for the interval of confidence in rejecting the null hypothesis is $p<0.05$, which is shown with the red dotted line. The statistics are expressed in the same space of the data (frequency). Note the average FRF plotted in black for the two sets. The average is performed in the complex domain; hence, plotting error bars with a measure of dispersion (e.g., STD) on magnitude and phase separately can be misleading (and ill-defined). The nature of the phase, i.e., an angle, may lead to jumps for values around 180°. This could be mitigated aesthetically by adding or removing 360° from the values to make the curves look "more continuous." However, it is generally an arbitrary choice, and a good alignment for all the FRFs phases may not be possible. In the sample plot, they have been aligned to be as close as possible to the mean.

Conclusions

Some advantages of applying 1-D statistics to FRFs for testing and visualizing the results have been presented. Future work will focus on making a set of standardized Matlab functions to analyze the FRFs available. In particular, nonparametric methods like the bootstrap presented in [3] will be implemented.

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Effects of postural interventions on mental and physical performance of children during secondary sexual characteristics

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Citation
Maekawa, M. Effects of postural interventions on mental and physical performance of children during secondary sexual characteristics.

Introduction

Posture and health are closely related. Moreover, various symptoms result from postural disorders. Previous studies have reported that improper posture in children at school and in everyday life might impact their postural development [1-3]. Children with secondary sexual characteristics who experience considerable physical, psychological, and social development are prone to physical and mental imbalances. The effects of postural intervention on the physical and psychological aspects and athletic performance in junior high school students in terms of secondary sexual characteristics were investigated in this study.

Methods

Of the 30 participants in this study, 21 (10 boys, 11 girls) with complete all measurements were included in the analysis. The postural intervention consisted of 1 month of direct muscle stretching for postural maintenance and breathing as well as activities to orient the spinal curvature. The participants' body arrangement, spinal curvature, General Health Questionnaire 30 (GHQ) scores, and athletic performance were compared before and after the postural intervention.

Results

The intervention improved postural alignment (e.g., head–neck angle $t_{20}=2.23$, $p<0.01$, 95%CI [0.30, 5.36]) and GHQ scores (e.g., GHQ total $t_{20}=3.36$, $p<0.01$, 95%CI [0.79, 3.40]). Correlations were found between postural and psychological measures (e.g., maximal extension and depression: $r=0.41$, $p=0.06$; and maximal extension and GHQ total: $r=0.42$, $p=0.05$). Of the 17 participants in the competition, 16 showed an improvement in athletic performance (time and distance).

Conclusions

Our results showed that the intervention improved the students' posture as well as had a positive effect on their mental health and physical performance. This study demonstrates that physical and psychological care for students during the period of secondary sexual characteristics can be provided without the use of special facilities or techniques.

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Impact of exercise program on dual-task walking speed compared to normal gait speed in patients with Parkinson's disease: Interim analysis

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Introduction
Parkinson's disease (PD) is a progressive neurodegenerative disease that leads to loss of locomotor automaticity [1]. Patients rely more on executive resources to control gait; they have higher dorsolateral prefrontal cortex activity compared to healthy older adults during usual walking [2]. Regular intensive training has been proven to improve cognitive functions with a reduction of prefrontal activity during walking [3]. The 5-meter walk test is a simple screening test used to assess functional mobility, gait, and vestibular function, requiring the patient to walk 5 m at a comfortable pace, turn at the 5 m mark and return to the starting point. A dual-task gait involves a simultaneous cognitive task combined with walking. In a study by Nosaka et al. the prefrontal cortex activation during dual-task walking was increased compared to normal walking [4]. In this study, we aim to compare the differences between the walking speeds in the 5-meter walk test and 5-meter with dual tasking before and after the intensive exercise program in patients with mild to moderate PD.

Methods
A group of 9 patients with idiopathic PD (mean age 63,88 ± 6,25 years, 6 males, disease duration 4,2 ± 3,2 years, all in the 2nd stage of Hoehn and Yahr classification) were subjects of the training plan consisting of a 4-month exercise program containing strength and aerobic coordination training, performed twice a week for 60 minutes. We recorded the walking speed of normal and dual-task gait pre-, mid- and post- intervention using the Microsoft Azure Kinect DK camera in ON (with regular dopaminergic medication) and OFF state (without dopaminergic medication). The cognitive task during dual-task walking required continuous subtraction of three from 107, vocalized by the patients. A comparison of walking speed differences between normal gait and dual-task between baseline and post-intervention measurements was performed with the paired Student´s t-test. The mid-intervention values, while recorded, were not directly relevant to this particular analysis. Future research may consider incorporating this variable into multivariate analyses.

Results

Although we did not find any improvement in any speed parameters between the two visits, we found a significant change in the difference between normal walking speed and dual-task walking speed in the OFF state. Our results are shown in Table 1.

TABLE 1: Group means of evaluated walking parameters in ON and OFF state from baseline, mid-intervention and post-intervention measurements

	Baseline	Mid-interven-tion *Not included in the statistical analysis	Post-inter-vention	P-value
ON STATE				
Normal walking speed (m/s)	1.1±0.18	1.21±0.14	1.12±0.13	0.47
Dual-task walking speed (m/s)	0.92±0.14	1.03±0.16	0.95±0.16	0.58
Speed difference (m/s)	0.18±0.1	0.18±0.08	0.17±0.1	0.94
OFF STATE				
Normal walking speed (m/s)	1.09±0.16	1.08 ±0.14	1.07±0.21	0.65
Dual-task walking speed (m/s)	0.88±0.16	0.88 ± 0.20	0.92±0.21	0.44
Speed difference (m/s)	**0.21±0.15**	0.20 ± 0.11	**0.15±0.14**	**0.04***

Conclusions

The observed reduction in the difference between walking and dual-tasking gait speed in the OFF state may support the finding of Hoang et al. [3], that intensive exercise in PD patients leads to a reduction of the prefrontal activity during usual walking and therefore patients have more mental capacity to perform other tasks during walking.

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Parameter identification of stance control in multiple neurological diseases

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Citation
Maurer, C. Parameter identification of stance control in multiple neurological diseases.

Introduction

It is well established, that stance control can be simulated using mathematical models comprising single or double inverted pendulums. These models usually use sensor fusion mechanisms to generate torque in joints relevant for balance control, such as in hip and ankle joints. Sensor inputs stem from visual, vestibular, proprioceptive, and force sensors. The fusion mechanism is a nonlinear algorithm, which can be expressed, for example, by thresholds. These models have proven to be able to approximate experimental results both during unperturbed, and perturbed stance. We aim here to apply an inverse dynamics like approach to identify physiologically meaningful alterations of sensorimotor stance control in elderly vs young subjects, and in different neurological diseases impairing stance control, such as polyneuropathy, vestibular deficits, pyramidal tract lesions, amyotrophic lateral sclerosis, Parkinson's disease, progressive supranuclear palsy, Huntington's disease, lumbar spinal canal stenosis, and in attention deficit disorder.

Methods
We performed stance control experiments in different patient groups both, for perturbed and unperturbed stance using different types of perturbations, e.g., body support platform tilts, or platform translations, in different sizes. From this data, we calculated transfer functions representing the relationship between external perturbations and body reactions. In addition, we characterized spontaneous behavior. Subsequently, we trained our models to closely reproduce experimentally derived data. Finally, we read out parameters, which were responsible for the change of simulated stance behavior of the model.

Results
We found changes in the stance control system of individual patients, which were specific for certain diseases, and have a physiologically meaning.
For example, we are able to quantify the underuse of proprioception in polyneuropathy patients, or overuse in patients suffering from vestibular deficits. Each disease seems to have its own pattern of altered stance control, exemplified by a typical set of parameter changes.

Conclusions
We hold that characterizing altered postural control in different patient groups by identifying parameter changes in models, which produce outcomes similar to experimentally derived data helps to classify different postural control deficits on a functional basis. This might help to target more precisely individual impairments by using specific balance training exercises. Moreover, we claim that this approach allows for a more detailed evaluation of therapeutic interventions, beyond simple phenomena, such as e.g., the amount of postural sway.

Plantar pressure distribution during quiet stance and gait in patients with incomplete spinal cord injury

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Citation
Mirando, M., Pavese, C., Nardone, A. Plantar pressure distribution during quiet stance and gait in patients with incomplete spinal cord injury.

Introduction

Balance impairment and changes in foot plantar pressure during standing and walking can be recorded with a baropodometric walkway [1,2]. Spinal cord injury (SCI) can affect postural stability due to lesions of either or both motor and sensory pathways [3] leading to a significant limitation to ambulation [4]. It is well known that in healthy subjects (HS), during gait, plantar pressure is unevenly distributed under the foot sole with higher pressure at the metatarsal bones and heel [5]. As the interface between the foot sole and the ground is the site where the contact forces are applied, it has been supposed that abnormalities of foot pressure distribution can explain balance and gait abnormalities in patients with SCI (PwSCI) [6]. We have shown that in HS foot pressure distribution is similar during quiet stance and gait [7] suggesting that it is possible to estimate pressure distribution during gait from their distribution during quiet stance. In the present study, we have assessed foot pressure distribution during quiet stance and gait in PwSCI and compared the results with those in HS. Furthermore, we investigated possible relationships between foot pressure values and sensory and motor findings, body sway during quiet stance and gait speed.

Methods

We enrolled 22 PwSCI (5 women) with incomplete lesion classified according to the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) [8] as ASIA Impairment Scale (AIS) D, aged 57.8±14.7 years and 22 age- and sex-matched healthy subjects (HS), aged 58.0±14.9 years. All PwSCI were capable to walk autonomously without aids. Plantar pressure was recorded during quiet stance and gait with a 4-m long baropodometric walkway (P-walk, BTS, Italy). Under quiet stance, the participant stayed upright, the arms stretched alongside the trunk with the hands in the supinated position, the feet forming an open angle of 30° with malleolus 5 cm apart. In order to uniform the position between the subjects, we used a foot template placed on the first panel of the platform, which is the one dedicated to the static measurements. Each subject performed two trials for each condition (quiet stance with eyes open (EO), and eyes closed (EC); and gait). The surface of the center of pressure (CoP) ellipse and path length of CoP were recorded with EO and EC for 30 s. The recording did not start immediately, but we waited about ten seconds to avoid recording any initial adjustments of the subjects. During gait, subjects were required to walk at their usual speed. Subjects were instructed to leave when they felt ready, and we also asked participants to start at least one meter before the beginning of the baropodometric walkway and to stop one meter after its end. Foot plantar pressure was recorded from 10 areas of the foot sole: T1, big toe; T2,3,4,5, toes 2 to 5; M1, metatarsal 1; M2, metatarsal 2; M3, metatarsal 3; M4, metatarsal 4; M5, metatarsal 5; MF, midfoot; MH, medial half of heel; LH, lateral half of heel. Mean peak plantar pressure (kPa) of both feet was extracted both during quiet stance and gait. Within each group, changes in foot pressures were assessed through a 2 (quiet stance and gait) x 10 (areas) repeated measures analysis of variance (rmANOVA).

Results

Under quiet stance with EO, mean surface of the CoP ellipse in HS and PwSCI was respectively 70.4±103.4 and 260.5±590.9 mm^2 whilst mean CoP path 150.6±45.6 and 197.6±96.2 mm, both measures being significantly ($p<0.01$) larger in PwSCI than in HS. With EC, mean surface of the CoP ellipse in HS and PwSCI was respectively 121.2±183.5 and 777.30±1105.8 mm^2, whilst mean CoP path 208.2±107.7 and 427.2±360.7 mm, both measures being significantly ($p<0.05$) larger in PwSCI than in HS. The ratio of surface or ellipse with EC to EO (Romberg quotient) was significantly greater in PwSCI than HS ($p<0.05$). Regarding plantar pressure distribution, mean peak pressure was similar in HS and PwSCI across all regions of the foot sole. In both subject groups, the highest pressure occurred at MH (HS: 58.1±17.9 kPa; PwSCI: 56.5±13.9 kPa) and LH (HS: 47.4±14.13 kPa; PwSCI: 47.7±13.8 kPa), significantly higher than at toes areas (rmANOVA, $p<0.05$). During gait, mean speed was 1.03±0.27 and 0.63±0.27 m/s ($p<0.05$), respectively in HS and PwSCI. In both groups, plantar pressure distribution was similar to that during quiet stance except for the absolute values that were higher (rmANOVA, $p<0.01$) during gait across all regions of the foot sole. The highest pressures were found in M2 (HS: 180±21.8 kPa; PwSCI: 169±26.9 kPa) and M3 areas (HS: 177±25.1 kPa; PwSCI: 165±22.7 kPa) ($p<0.01$). In both groups, a significant correlation was found between corresponding areas of foot pressure during gait and quiet stance: HS, $y=2.1x+62.9$, $p<0.005$, $R^2 = 0.73$; SCI, $y = 2.1x + 47.51$, $p<0.005$, $R^2 = 0.75$. In PwSCI, no correlation was found between the Romberg quotient and asymmetry of limb loading during quiet stance as well as with ISNCSCI subscores (lower extremity muscle strength, pin prick and light touch sensation from both body sides). No relationship was found between foot pressure values and surface or path of CoP during quiet stance, and gait speed.

Conclusions

Results show that peak plantar pressure and its pattern of distribution at the foot sole during quiet stance and gait are similar in PwSCI and HS. This finding suggests that the observed balance and gait disorders in PwSCI are not completely explained by abnormalities in plantar pressure values and distribution. This result is at odds with those by [6] and might be in part explained by the fact that in our study PwSCI showed incomplete lesions and were capable to walk independently without aids. During quiet stance, both subject groups loaded more on heels, while during gait pressures were higher at the metatarsal areas. This finding is presumably connected with the forward propulsion of the center of mass during gait. The similarity in the distribution of plantar pressure suggests that also in PwSCI, as in HS [7], it is possible to estimate rather accurately pressure distribution during gait from its distribution during quiet stance. As expected, pressures in all foot areas were significantly higher during gait than quiet stance in both subject groups. This difference in plantar pressure between gait and stance is in accordance with the larger dynamic components of gait. In addition, it should be considered that during gait plantar pressures were recorded in single stance support whilst under quiet stance in double support, thus halving the forces acting on the ground.

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The effect of minimalist footwear wearing on plantar pressure during walking

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Citation
Murínová, L., Klein, T., Svoboda, Z., Janura, M. The effect of minimalist footwear wearing on plantar pressure during walking.

Introduction
The public's interest in wearing minimalist footwear is rising in recent years. Its characteristics, as a shape that respects the foot morphology, wide toe box, flat and thin sole, which is flexible in all directions, no cushioning, and low weight, should enable better perception of the terrain, more natural movement of the foot and positively affect the stereotype of walking and the entire musculoskeletal system of the individual [1-5]. Recent studies show that wearing minimal footwear influences muscle strength and cross-sectional area of selected foot muscles or improve postural and walking stability [5-7]. To understand more comprehensively the effect of minimalist footwear on an individual's musculoskeletal system, it is necessary to focus on monitoring different characteristics of gait and to combine the knowledge gained from different areas of research, especially long-term research.

Methods
Fifty healthy adults were divided into experimental group (EG: 16 females and 9 males of age 26.00±5.27, height 174.28±10.47 cm, weight 70.84±16.02 kg)

and control group (CG: 14 females and 11 males of age 26.08±4.35, height 174.74±9.59 cm, weight 69.36±10.67 kg) by randomization. The experimental group wore minimalist footwear Chitra Bare (Ahinsa Shoes®, Walk free, s.r.o., Prague, Czech Republic) in the recommended, slowly increasing volume for six months (the intervention period from May to November). The control group wore their own conventional footwear in that period. Plantar pressure variables (% contact – a percentage of contact time with the platform, impulse – pressure time integral, maxP - peak pressure, tMaxP – a percentage of time of maximum pressure) in both groups were measured while barefoot walking at a self-selected speed on the Footscan® platform system (RSscan International NV, Paal, Belgium) before and after the intervention period. Statistical comparison between groups before the measurement was performed using the Mann-Whitney U test. The Wilcoxon test was used to assess the effect of the intervention in each group separately.

Results

In comparison between groups, the significant difference was found only for the maxP in the medial and lateral heel areas. In the experimental group after the intervention period, the results showed a significant decrease in % contact in the medial (p=0.032) and lateral (p=0.021) heel area on a non-dominant (ND) lower limb, a significant decrease in % contact in the medial heel area (p=0.030) on a dominant (D) lower limb, a significant increase in maxP on the big toe area (p=0.030) on a ND lower limb and significant decrease in tMaxP at lateral heel area (p=0.020) of the D lower limb. In these variables, no significant difference was found in the control group. The main % contact differences in heel areas are shown in Fig. 1.

Conclusions

Six months of wearing minimalist footwear reduced contact time of the heel area, especially on the non-dominant foot, and moved loading more distally to the big toe in walking. The results could suggest a change in the foot strike pattern and foot off on the non-dominant lower limb. Still, to confirm this suggestion, it would be necessary to put the resulting data in the context of functional lower limb dominance and kinematic analysis of the gait.

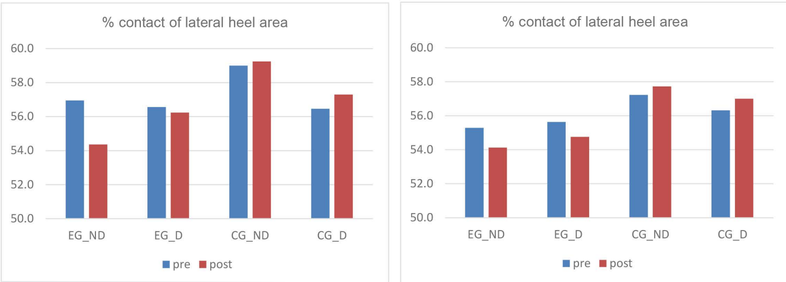

FIGURE 1

Comparison of % contact in heel area between experimental and control group pre and post intervention. EG_ND - experimental group, non-dominant lower limb; EG_D – experimental group, dominant lower limb; CG_ND – control group, non-dominant lower limb; CG_D – control group, dominant lower limb.

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Gait and balance abnormalities of patients with heart failure are not only related to heart function

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Introduction

Heart failure (HF) affects most systems of the body leading to multiple comorbidities [1]. In patients with heart failure (PwHF), the distance traveled at the Six Minutes Walking Test (6MWT) is reduced [2], a sign of decreased exercise tolerance [3]. The 6MWT does not, however, allow to discriminate the role of the neuromotor component with respect to the components purely connected to cardiovascular and respiratory functions in determining the reduction of locomotor performance. In this regard, it can be recalled that in patients with chronic obstructive pulmonary disease (COPD) gait and balance worsening explain part of the long-distance locomotor impairments measured with the 6MWT [4], suggesting that this test is not only influenced by the respiratory impairments. In addition, the complex clinical picture of PwHF involves also alterations of gray matter and axonal damage in brain regions, including the cerebellum [5], responsible for the control of motor activity. Therefore, these alterations could contribute to poor postural control [6] and reduced locomotion speed [7] that would occur in these patients [8]. As a consequence, the 6MWT might be affected by these changes in addition to mere cardio-pulmonary deconditioning. Aims of this study were to quantify alterations in balance control and gait in PwHF, to compare them to healthy controls and to assess if the alterations affect the 6MWT.

Methods

We have recruited 19 patients, aged 70.0±12.7 years, 15 men and 4 women, from the Cardiac Rehabilitation Unit, ICS Maugeri of Pavia, admitted with diagnosis of HF; patients with any other condition or disease known to affect gait or balance (orthopedic surgery involving the lower limbs, vestibular and neurological diseases, heart failure in acute congestive phase or in continuous infusion therapy or New York Heart Association IV, diabetes, COPD) were excluded. In addition to clinically evaluating lower limb muscle strength and sensation, we evaluated the spatiotemporal gait variables over a short path (4-m baropodometry), the distance traveled at the 6MWT, balance control through the Mini-BESTest (MBT, score range 0-28), and hand grip strength with dynamometry. Results are reported as mean ± standard deviation. Statistical analysis was performed through the unpaired Student's t-test. P value <0.05 was considered significant.

Results

At physical examination, PwHF did not show lower limb muscle weakness or impaired sensation. Table 1 shows that gait variables measured with baropodometry were significantly abnormal in PwHF with respect to 20 age- and sex-matched healthy subjects (HS), aged 70.9±8.6 years. The traveled distance of PwHF at the 6MWT was on average 321 m, significantly below (p<0.005) the predicted value of 434 m [2]. The MBT of PwHF scored

TABLE 1: Gait variables measured with baropodometry

Baropodometry	HS	PwHF	P
Gait speed (m/s)	1.08±0.12	0.92±0.23	<0.004
Cadence (steps/min)	108.9±11.2	92.7±16.3	<0.0005
Step length (cm)	58.8±4.7	52.8±9.4	<0.001
Step width (cm)	25.5±3.7	28.7±4.9	0.01

on average 16, corresponding to moderately severe deficit of balance control [9]. The hand grip test of PwHF was on average 23.6 kg, similar to its predicted value [10]. In PwHF, significant correlations were found between 4-m speed and MBT ($y = 0.03x + 0.6$, $P<0.0005$, $R^2 = 0.56$), and between 6MWT and gait speed ($y = 491.0x - 132.6$, $P<0.0005$, $R^2 = 0.68$). Finally, a significant correlation was found also between 6MWT and MBT ($y = 18.4x + 12.0$, $P<0.0005$, $R^2 = 0.64$).

Conclusions

As expected, the 6MWT was reduced in PwHF. However, 6MWT was clearly affected by the impairment of balance control measured with MBT. In turn, gait speed measured over a short path with baropodometry was also abnormal and affected by balance impairment. In addition, gait speed affected the distance traveled at the 6MWT suggesting that it is possible to estimate quite accurately the distance traveled at the 6MWT from the gait speed over a short path. All together, these findings suggest a role of altered neuromotor control in reducing exercise tolerance in addition to mere cardio-pulmonary deconditioning. The absence of clinical signs of lower limb muscle weakness and sensory impairment suggest a role of central rather than peripheral nervous system lesions in producing balance and gait disorders in PwHF [5]. This statement is further sustained by the finding that handgrip strength, that is considered a valid method to estimate lower limb strength among older adults [11], turned out to be normal in PwHF. Finally, slow gait speed *per se* might further contribute to reduced exercise tolerance, due to the high energy cost of slower than normal walking [12].

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Video-based quantification of the Pull Test to objectify clinical assessment of postural instability in parkinsonian syndromes

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Introduction

Postural instability and falls are major complications in advanced Parkinson's disease (PD). Clinical evaluation of postural instability in PD and related movement disorders is most commonly based on the Pull Test (PT) that examines the ability to recover from a backward pull on the shoulder, which closely correlates with patients' risk of falling [1]. Clinical application of the PT suffers, however, from several shortcomings such as lack of consensus on the proper execution and a subjective scoring system that both contribute to a low intra- and inter-rater reliability [2]. Here, we seek the potential to objectify the execution and patient performance during PT by means of video-based markerless pose tracking.

Methods

We apply a deep-learning-based multi-person pose estimation [3] on RGB-D recordings (Microsoft kinect azure) to extract whole-body kinematics during PT examination. Based on the extracted kinematic data, we both objectify PT execution (i.e., pull magnitude) and quantify postural responses of participants by a number of established parameters (i.e., pull-to-step latency, number of steps, etc. [4]). In a first step, we then evaluate the concurrent validity of this approach by comparison to a gold standard approach, i.e., marker-based pose tracking (Qualisys AB, Sweden) in a cohort of young healthy individuals (N=16) based on the intraclass correlation coefficient (ICC). In a second step, we examine the intra-session reliability of our approach in healthy individuals (N=18) with two different examiners (DP & AZ) and finally evaluate how well our approach can discriminate healthy from pathological postural responses in patients with parkinsonian syndromes (N=7).

Results

Our approach yields excellent concurrent validity with the gold standard assessment both in terms of objective monitoring of PT execution (pull magnitude) and quantitative assessment of postural responses (Table 1). Repeated assessment of PT with different examiners in healthy individuals shows high consistency (Fig. 1A-F). Patients exhibit compromised postural reactions in terms of shorter and slower stepping responses and a higher number of steps required to regain balance (Fig. 1A-F) – alterations that allow to reliably discriminate pathological from healthy PT performance (Fig. 1G).

TABLE 1: Concurrent validity of our approach (kinect) with the gold standard (Qualisys) was evaluated by Pearson's correlation coefficient (R) and intraclass correlation coefficient (ICC)

Parameter	Kinect	Qualisys	R	ICC
pull magnitude (m/s^2)	2.5 ± 1.1	2.7 ± 1.1	0.93	0.96
1st step latency (s)	0.8 ± 0.5	0.9 ± 0.5	0.99	0.99
1st step duration (s)	0.3 ± 0.1	0.3 ± 0.1	0.86	0.92
1st step length (m)	0.3 ± 0.1	0.3 ± 0.1	0.87	0.93
1st step peak velocity (m/s)	1.4 ± 0.3	1.3 ± 0.2	0.84	0.90
# steps	1.8 ± 0.6	1.6 ± 0.6	0.82	0.90

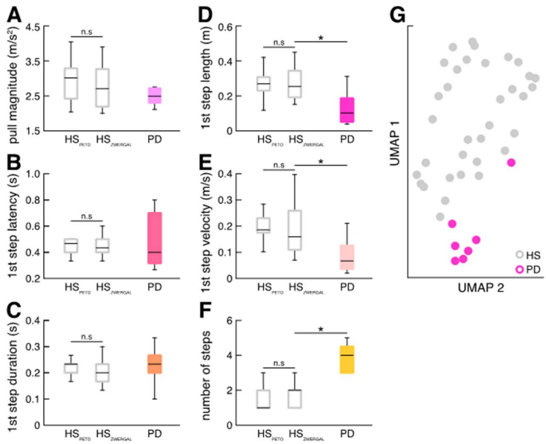

FIGURE 1

(**A-F**) Repeated assessment of PT with different examiners in HS shows high consistency with respect to PT execution (pull magnitude) and participants' postural responses. In correspondence to literature [4], patients with PD exhibit compromised postural reactions in terms of shorter and slower stepping responses (**D, E**) and a higher number of steps (**F**) required to regain balance. Low-dimensional embedding of the latter features (Uniform Manifold Approximation and Projection, UMAP) indicates that our method can reliably discriminate pathological from healthy performance (**G**).

Conclusions
Video-based quantitative PT assessment represents a low-cost and effortless approach that yields excellent concurrent validity and reliability and may thus facilitate increased sensitivity and specificity of clinical assessment of postural instability and risk of falling in PD.

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The current state of sex- and gender-based analyses in standing balance research: A scoping review

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Introduction

Balance control is undeniably important and highly related to physical and emotional wellbeing [1]. Understanding how sex and gender impact balance is critical [2] if scientists are to provide enhanced, relevant, and sensitive knowledge. Sex- and gender-based analyses (SGBA) go beyond determining group proportions and/or aggregating data with the aim to understand differences resulting from different sex and gender [3]. "Male" and "female" are terms used to categorize sex and used to reflect biological attributes, while gender is a social construct that can be categorized across a spectrum of identities [3]. Consistent and accurate use of sex- and gender-based terminology within a study is important to clarify the role of sex and gender in the research findings; however, given inconsistent application of definitions and terminology, it is difficult to discern the accuracy of labels applied to different groups. The Sex and Gender Equity in Research (SAGER) guidelines provide a framework for researchers to report sex and gender in research [3]. The main purpose of this research was to examine SGBA and the use of sex- and gender-based terminology in current standing balance research according to the SAGER guidelines.

Methods

Following an established scoping review framework [4], the primary research questions included: "What is the frequency and type of SGBA in standing balance research?", "What is the consistency of sex- and gender- based terminology use in standing balance research?", and "How do sex- and gender-based labels align with operational definitions?" Search strategies were applied to eight databases including Medline, PubMed, Embase, APA PsycINFO, SPORTDiscus, Web of Science, and Scopus. Search results were deduplicated in Endnote X9 (version 20) and exported to Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) for abstract and full-text screening. To be included, articles needed to be peer-reviewed, published in 2020, and quantitatively measure standing in adult humans using a biomechanical construct [5]. Review articles, commentaries, case studies, and studies focused on machine learning, finite element modelling, network analyses, or psychometric testing of measures were excluded. Two independent reviewers screened abstracts and extracted data with a third reviewer resolving conflicts. Data to support the questions about consistency and use of terminology were extracted by one reviewer after 75 % between-reviewer agreement was found. Data extraction questions were developed iteratively and guided by the SAGER guidelines [3]. Data related to participant demographics, inclusion and type of sex- and gender-related analyses, the consistency of sex and gender terminology, and alignment with definitions (e.g., male/female labels defined as sex-based characteristics) were collected. SGBA was operationally defined as analyses that tested for sex- and/or gender-based differences in outcome variables, whether sex and/or gender is related to or predicts change, or included sex and/or gender as a covariate [3]. Absolute and relative values across all articles and within collaboratively created categories were calculated.

Results

The initial search returned 5612 articles. After full-text screening, 411 articles were included. Neurotypical adults was the most common population group (n=169, 41 %), followed by people with central and peripheral nervous system impairments (n=97, 24 %), people with musculoskeletal impairments and limb loss (n=49, 12 %), neurotypical older adults (n=38, 9 %), neurotypical adults and neurotypical older adults combined (n=37, 9 %), with the lowest participant category being the 'other' category (n=21, 5 %). Twenty percent of all retained articles (n=84/411) included sex and/or gender in the statistical analyses with the lowest proportion in studies with neurotypical adults (n=18/169, 11 %) and neurotypical older adults (n=8/38, 21 %), and highest in the 'other' category (n=8/21, 38 %). The most common analyses tested for differences in the proportion of sex and/or gender between groups within a study (n=57/411, 14 %) with the lowest relative testing of group proportions in the neurotypical adult groups (adults n=4/169, 2 %; older adults n=6/38, 16 %; combined n=3/37, 8 %), and highest in the central and peripheral nervous system impairments (n=25/97, 26 %), musculoskeletal impairments and limb loss (n=13/49, 27 %), and "other" groups (n=6/21, 28 %). Ten percent (n=42/411) of articles included some type of SGBA. The percentage of articles which tested for sex and/or gender differences in biomechanical constructs was six percent (n=23/411) for all articles, highest within the neurotypical adult group (n=16/169, 10 %), and lowest within the musculoskeletal impairments and/or limb loss group (n=0/49, 0 %). The use of sex and/or gender as a covariate was used in one percent (n=6/411) of all included articles and only seen in the central and peripheral nervous system impairments group (n=5/97, 5 %) and the older adult group (n=1/38, 3 %). Three percent (n=13/411) of all articles tested whether sex and/or gender is related to or predicts change in biomechanical constructs, with the lowest and highest relative use in the musculoskeletal impairments and limb loss group (n 0/49, 0 %) and 'other' group (n=3/21, 1%), respectively. Fifty-seven percent of all articles (n=234/411) used consistent sex and/or gender-based terminology with articles that included only neurotypical adults having the highest percentage of consistent terminology use (n=118/169, 70 %). Thirty-six percent (n=146/411) did not use terminology consistently and seven percent (n=27/411) did not include sex- and/or gender-based terminology at all. Twelve percent (n=50/411) of all articles used terminology aligned with operational definitions, with the highest proportion in studies examining central and peripheral nervous system impairments (n=22/97, 23 %) and the lowest proportion in studies examining neurotypical young and older adults combined (n=0/37, 0 %). Most often (n=184/411, 45 %), studies used terminology without definitions (e.g., used female/male but did not specifically define the groups as based on sex). Eighteen percent (n=72/411) of articles used terminology consistently but not aligned with definitions (e.g., female/male used as labels under the category of gender) with the same values (n=72/411, 18 %) for articles that inconsistently used terminology and definitions. One percent (n=4/411) of all articles defined groups as sex or gender but did not apply any terminology in the text of the article.

Conclusions

One in five articles included some sex- and gender-related statistical analyses with most comparing proportions of participants based on sex/gender and only ten percent including SGBA. The majority of reviewed articles used terminology consistently and aligned that terminology with sex- and/or gender-based definitions. Interestingly, articles with neurotypical adults had the most consistent and aligned use of terminology but the lowest use of SGBA. These results point to a need for increased SGBA, and consistent, definition-aligned reporting of terminology to enhance our understanding of how sex and gender influence standing balance.

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Real world balance assessment: Insights into association with clinical outcomes

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Introduction

Impaired balance is a prevalent issue among older adults and has significant implications for their functional independence and quality of life. Several studies have used force plates or wearable sensors to assess balance in the laboratory. Still, assessment of balance in real-world settings has not been studied yet. Wearable devices have demonstrated potential in capturing relevant mobility parameters in real-world environments [1], offering the advantage of unobtrusive monitoring. In this study, we aimed to evaluate real-world balance features and evaluate their association with clinical outcomes in community-dwelling older adults.

Methods

In our study, we leveraged data from 168 community-dwelling older adults of the 4th follow-up of the InCHIANTI study, a longitudinal cohort study of aging in the Chianti region of Tuscany, Italy [2]. Participants wore a smartphone-based sensor on their lower back both in the laboratory and real-world settings. Clinical information was assessed from the participants at the laboratory, where participants performed a Romberg test (in this study we evaluated the 30 seconds of quiet standing with open eyes). Following the test, they were instructed to wear the smartphone sensor for a week-long monitoring period in their daily lives. The smartphone sensor, embedded with a tri-axial accelerometer and gyroscope, recorded signals at a sampling frequency of 100 Hz. From the monitored data, we identified standing events with a duration of at least 30 seconds by detecting stationary periods between gait and sitting transfers. Balance features, including acceleration range, distance, mean frequency, jerk, sway area, and 95th percentile frequency were extracted from both the laboratory and real-world assessments. Features were averaged for each participant. A Welch t-test was used to compare kinematic characteristics between two clinical outcomes - medication and cognitive function. P-values were adjusted for false discovery rate.

Results

Association between balance features and four clinical outcomes was evaluated: the number of medications (more than 3 drugs), mild cognitive impairment (MCI), evaluated with the Mini-Mental State Examination (MMSE) score (≤24), age (>75 years), risk of depression (CESD≥16), and questionnaire-based physical activity. Under laboratory conditions, no significant differences were found for any clinical outcome. In the real-world setting instead, antero-posterior (AP) range and area showed significant differences regarding number of medications, being reduced in people using more medications (Table 1). Regarding MCI, AP and medio-lateral (ML) range and distance exhibited significant differences in the real-world assessment (Table 2), being reduced in people with mild cognitive impairment. Smoothness was significantly lower for people with MCI. Regarding depression, people at risk had a significantly lower AP range. Regarding age, sway area was significantly lower in people over 75 years old. No association was instead found with PA assessed from questionnaires.

TABLE 1: Number of medications

		Laboratory			**Real-world**	
Feature	**≤ 3 medications**	**>3 medications**	**p-value**	**≤ 3 medications**	**>3 medications**	**p-value**
AP Acc Range	0.448±0.565	0.356±0.142	0.558	0.692±0.084	0.656±0.083	**0.027**
ML Acc Range	0.404±0.864	0.312±0.263	0.558	0.71±0.142	0.687±0.124	0.328
Distance	0.05±0.032	0.047±0.015	0.558	0.071±0.014	0.068±0.013	0.328
mean Frequency	0.159±0.016	0.159±0.021	0.903	0.166±0.012	0.164±0.014	0.328
Area	0.04±0.113	0.023±0.01	0.558	0.044±0.012	0.039±0.012	**0.027**
Jerk	-14.891±0.451	-14.827±0.469	0.558	-14.308±0.335	-14.283±0.282	0.547
95% Freq	43.392±3.108	43.583±1.744	0.725	41.192±1.471	41.107±1.211	0.547
Stands/h	/	/	/	1.329±0.825	1.465±0.789	0.328
Duration	/	/	/	40.853±1.289	40.928±1.23	0.547

TABLE 2: Cognitive impairment

		Laboratory			Real-world	
Feature	**MMSE>24**	**MMSE≤24**	**p-value**	**MMSE>24**	**MMSE≤24**	**p-value**
AP Acc Range	0.376±0.228	0.652±1.106	0.454	**0.68±0.084**	**0.622±0.076**	**0.015**
ML Acc Range	0.312±0.411	0.782±1.572	0.454	**0.711±0.131**	**0.592±0.115**	**0.002**
Distance	0.048±0.022	0.059±0.046	0.454	**0.071±0.013**	**0.06±0.01**	**0.002**
mean Frequency	0.159±0.016	0.16±0.03	0.84	0.165±0.013	0.166±0.015	0.493
Area	0.026±0.03	0.083±0.235	0.454	0.042±0.013	0.037±0.01	0.065
Jerk	-14.874±0.438	-14.735±0.616	0.454	**-14.279±0.309**	**-14.45±0.289**	**0.037**
95% Freq	43.625±2.239	42.232±4.209	0.454	41.085±1.332	41.734±1.393	0.065
Stands/h	/	/		1.391±0.804	1.425±0.872	0.493
Duration	/	/		**40.805±1.232**	**41.639±1.267**	**0.026**

Conclusions

Significant associations were found between real-world balance features and clinical outcomes. No significant association was instead found from the laboratory assessment. From this exploratory analysis, lower postural sway was found in the real-world for people using multiple medications, people with MCI, older people, and people at risk of depression. We speculate that lower postural sway could be associated to rigidity, lack of confidence, and possibly less adaptability to the challenges of real-world environments. The association with mild cognitive impairment seemed the strongest, where it was also found that smoothness of postural sway was reduced in people with MCI (possibly linked to rigidity) and that the average standing duration was longer in people with MCI (it should be further evaluated whether this can be linked to a more static/sedentary activity pattern). The results of our study highlight the potential of real-world balance assessment by using wearable sensors. The findings support previous studies that have emphasized the advantages of wearable technologies in capturing meaningful mobility parameters in daily life [1]. Such real-world assessments enable a more comprehensive evaluation of an individual's balance function, taking into account the dynamic challenges encountered in their natural environment.

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Human balance control – Beyond sensory integration

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Citation
Peterka, R.J., Campbell, K.R., King, L.A. Human balance control – Beyond sensory integration.

Introduction

Investigations of the control of standing balance often focus on the role of sensory utilization and integration as a function of changes in environmental conditions and in various patient populations with sensory deficits and neurological conditions. By applying an analysis based on a closed-loop feedback balance control model, body sway responses to pseudorandom rotations of the stance surface and/or visual scene provide measures of the extent to which proprioception, vestibular, and visual systems are combined (a weighted combination) to form an internal estimate of body orientation [1]. However, balance control also relies on the appropriate generation of corrective joint torques that are necessary to overcome the destabilizing torque due to gravity and to control body posture as a function of the internally derived estimate of body orientation. Additionally, central processing time is needed for sensory integration and motor command generation.

The combination of central processing time delays and additional neural transmission and muscle activation delays can be long enough that they influence the stability of the closed-loop feedback balance control system. Specifically, long time delays can adversely affect stability. Early work [1] indicated that time delays were consistent across subjects and that motor responses scaled in proportion to the destabilizing gravity torque that is a function of body mass and height of the body center-of-mass (CoM). However, recent results in subjects with chronic balance complaints (>3 months) following mild traumatic brain injury (mTBI) indicate that excessive time delays and reduced corrective torque generation can be a major contributor to deficits in standing balance control [2]. Additionally, the balance control behavior exhibited by subjects with long time delays and reduced torque generation leads to patterns on Computerized Dynamic Posturography (CDP) sensory organization tests (SOTs) that can be interpreted as being 'aphysiologic' [2,3].

Methods

The study investigating balance control in mTBI subjects included 52 subjects with chronic (>3 months) unresolved mTBI symptoms and 58 healthy controls (HCs) [2]. Subjects' balance control was assessed using: 1) Central Sensorimotor Integration (CSMI) tests that perturbed balance using repeated 20-s duration cycles of 2° (peak-to-peak) pseudorandom rotations of the stance surface and/or visual surround that evoked anterior-posterior CoM sway [2,4], and 2) conventional CDP SOT with both tests performed on a SMART EquiTest CRS Balance Manager system (Natus Medical Inc, Seattle WA). The CSMI test identified parameters of a balance control model by adjusting parameter values to optimally account for the stimulus-evoked CoM sway. The parameters include sensory weights (indicating the relative contribution of sensory systems to balance), overall system time delay, and motor activation 'stiffness' and 'damping' parameters that define the amount of ankle torque generated in proportion to sensory-derived estimates of body sway angle and angular velocity, respectively. Here we focus on results from eyes-closed CSMI tests that yield an estimate of the vestibular weight, on the time delay measure, and on a normalized stiffness parameter (normalized by dividing by body mass x CoM height x gravity constant). SOT results were analyzed using conventional normalized measures of sway in the 6 sensory test conditions. Additionally, we applied the classification analysis developed by Cevette et al. [3] to categorize SOT sway patterns of subjects into 'normal', 'vestibular dysfunction', or 'aphysiologic' categories.

Results

CSMI results showed essentially identical reliance on vestibular orientation cues for balance among chronic mTBI and HCs (vestibular weight 0.48±0.07 SD for mTBI, N=49 (3 did not complete testing); 0.49±0.08 for HCs, N=58). Across both HC and mTBI groups time delay was inversely correlated with normalized stiffness (r= -0.59) indicating that subjects with longer time delays also tended to have lower normalized stiffness. Additionally, there was a subgroup of mTBI subjects who had particularly long time delays and low stiffness values. This subgroup was clearly distinguishable from HCs. Specifically, using normative paramater ranges based on 10th percentile HC cutoffs for low stiffness and long time delays, 14 of 49 (29 %) mTBI subjects had both low stiffness and long time delays compared to only 1 of 58 (2 %) HCs. The Cevette classification of mTBI subjects showed that 22 of 49 (45 %) mTBI subjects were categorized as showing an aphysiologic pattern compared to only 2 of 58 (3 %) HCs. Among the mTBI aphysiologic subjects 10 of the 22 (45 %) also were in the low stiffness/long time delay subgroup. Neither of the 2 HCs classified as aphysiologic had both low stiffness and long time delays.

Conclusions

Results from our study of mTBI subjects with chronic imbalance complaints showed that they did not have an abnormal ability to utilize vestibular sensory information for balance control [2]. However, a notable subgroup of the mTBI subjects had both long time delays and low stiffness. Long time delays in a feedback control system are incompatible with stability. But the stiffness and damping parameters also determine whether the system is stable for a given time delay. As time delays increase, an effective compensation for an increased delay is to decrease motor activation parameters of stiffness and damping. The relationship between stability, time delay, and motor activation provides a reason why time delay and normalized stiffness were negatively correlated and suggests a hypothesis that increased time delay was the fundamental abnormality affecting balance in a significant subgroup of mTBI subjects. That is, their brain injury slowed central sensory integration and motor command generation and they compensated by reducing motor activation. However, while the compensation is effective for maintaining a stable system it has the negative consequence that the destabilizing influence of gravity has a greater influence resulting in a 'sloppy' balance control system that could leave a subject vulnerable to falls from relatively small balance disturbances. The Cevette classification of a large fraction of chronic mTBI subjects into the aphysiologic category and the fact that a number of the aphysiologic subjects also had low stiffness and long time delays suggests a possible physiological explanation for aphysiologic behavior. However, there are caveats. The Cevette classification was an early attempt at a classification scheme based only on SOT results. The Cevette classification scheme specifically means that our subjects who were classified as aphysiologic had results closer to that category than to the normal or vestibular dysfunction categories. Later studies applied additional criteria that could result in fewer aphysiologic classifications based on additional tests [5]. A future consideration could be to determine whether CSMI methods can give insight into other balance and dizziness syndromes such as persistent postural-perceptual dizziness (PPPD). For example, we note that a study of PPPD patients by Söhsten et al. [6] showed a pattern of SOT results that were consistent with some criteria defining aphysiologic behavior [5] and showed a pattern of sway measures across the 6 SOT conditions that were similar to our chronic mTBI subjects. The quantification of balance behavior using methods that account for the closed-loop nature of the balance control system has the potential to enhance our understanding of balance disorders that currently are poorly understood.

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The effects of cognitive demand on distributions of mediolateral plantar pressures while walking in anxiety-inducing virtual settings

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Citation
Raffegeau, T.E., Fleming, P., Stark, N.E.P., Fino, P.C. The effects of cognitive demand on distributions of mediolateral plantar pressures while walking in anxiety-inducing virtual settings.

Introduction

Walking in everyday life requires managing mobility-related anxiety and simultaneous cognitive tasks (i.e., dual-task). Young adults trade-off between cognitive and locomotor task performance during a dual-task, even during a well-practiced concurrent task like conversational speech [1]. Mobility-related anxiety also induces changes in balance despite no added motor demands; physically lifting participants to high elevation elicits 'stiffening of posture' (i.e., reduced sway) [2] and gait (i.e., slower gait speeds) [3], with similar effects on posture and gait detected at high elevation in virtual reality

(VR) settings [4,5]. Daily life can involve both dual-tasking and anxiety-provoking environments (such as walking while talking with a friend and crossing a busy street). Few studies combine the demands of daily tasks to examine their effects on mobility, instead focusing on laboratory-based dual-tasks [6]. The purpose of this study was to examine changes to locomotor balance control during conversational speech, an ecologically-relevant daily dual-task, in anxiety-inducing settings. We predicted that cognitive demand and mobility-related anxiety would affect mediolateral balance during walking, indicated by the change in the distribution of medial and lateral plantar pressure during single support.

Methods

Participants wore a commercial wireless (HTC Vive) head-mounted display (Unity 3D) as part of a larger study. Pressure-sensing insoles (loadsol-acp, Novel®) were worn in the participants shoes and medial, lateral, and rear loads were recorded during walking. After a two-minute familiarization period, virtual experimental conditions were delivered in two blocks ensuring the participant experienced the virtual low elevation setting prior to the high elevation setting (15-meter elevation). After familiarization, participants were randomized and counterbalanced into completing the single-task (ST) or dual-task (DT) block first. For ST, participants walked on a 5.2 x 0.4 meter walkway at a self-selected pace in virtual low and high elevation settings for one minute. For the DT, participants were assigned a selected topic to speak about continuously while walking at a comfortable pace. After each condition, participants rated their levels of cognitive and somatic anxiety, and how confident they were in their ability to complete the task (rated from 1-11) [7], and the level of mental effort required to complete the task on a scale from 1-150, where 150 represents maximal mental effort [8]. Balance control during walking was estimated by extracting straight steps using a publicly available visualization interface [9] that was modified for the loadsol three-compartment signal in MATLAB (v2022b). Mediolateral pressure distributions were examined by calculating the difference between the medial and lateral pressure at 30 % of the stride (midstance), representing mediolateral pressure distribution of the stance foot during the single support phase of gait. A larger value represents a bigger difference and relatively lateral position of the center of pressure on the foot, requiring a larger corrective action (e.g., larger ankle torques) to maintain balance [10]. A value approaching zero indicates a relatively centered position of the center of pressure on the foot, requiring smaller corrective motions to maintain the center of mass within the base of support [10]. For statistical comparisons, we analyzed the absolute values for the mediolateral pressure differences at midstance for each foot using R Studio to test a linear mixed regression model comparing Condition (2 levels: ST, DT) by Height (2 levels: Low, High) including a random effect of subject and step. Effect sizes corrected for small samples (Hedges' *G*) compared changes in ratings responses between ST and DT at low and high height.

Results

Insoles were fitted onto a subsample of participants (N = 8, five women, height = 1.7 (9.1) meters, weight = 71.8 (11.5) kilograms). The model supported that experimental condition significantly affected the distribution of medial and lateral plantar pressure, such that a significant effect of height was detected (B = -0.038, p = .002) but not cognitive demand (B = -0.002, p = .843). The interaction effect was of a similar magnitude, but did not reach significance (B = -0.031, p = .074). Participant ratings showed that at low heights, the dual-task elicited more worried thoughts (ST: 1.4 ± 0.5, DT: 2.4 ± 1.3, mean difference = 1, *G* = 0.9), feelings of more body tension (ST: 2.0 ± 1.1, DT: 2.8 ± 1.1, mean difference = 0.8, *G* = 0.6), less confidence to complete the task (ST: 10.3 ± 0.7, DT: 9.7 ± 0.8, mean difference = -0.6, *G* = -0.7), and higher levels of mental effort (ST: 18.9 ± 11.7, DT: 28.9 ± 10.5, mean difference = 10.0, *G* = 0.8). Conversely, dual-tasks at high heights elicited less worried thoughts (ST: 5.3 ± 1.6, DT: 4.7 ± 1.2, mean difference = -0.66, *G* = -0.42), feelings of less body tension (ST: 5.9 ± 1.5, DT: 5.0 ± 1.9, mean difference = -0.8, *G* = -0.47), more confidence to complete the task (ST: 7.1 ± 1.7, DT: 8.4 ± 1.1, mean difference = 1.3, *G* = 0.8), and similar levels of mental effort (ST: 48.9 ± 11.7, DT: 48.9 ± 14.5, mean difference = 0.0, *G* = 0).

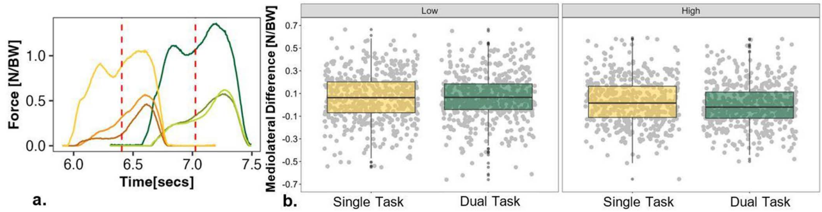

FIGURE 1
The distribution of medial and lateral plantar pressure was calculated as the differences between the mediolateral signals at midstance **(a)** to estimate the change in balance control due to condition **(b)**.

Conclusions

Walking in anxiety-inducing settings altered the distribution of plantar pressures on the mediolateral aspect of the foot, but cognitive demands of conversational speech resulted in no change of the distribution of plantar pressure. At high elevation, participants minimized differences between mediolateral plantar pressures under both ST and DT demands (Fig. 1), aligning with the theory that people 'stiffen' their balance control when they experience postural threat [11], which would serve to enhance gait stability in anxiety-inducing settings [9]. Conversational speech is a well-practiced cognitive task, but the ratings support the way participants perceived the cognitive demands of the speech task was dependent on their level of mobility-related anxiety. Performing the DT reduced their self-reported levels of anxious thoughts and body tension at high elevation, suggesting that the DT may have served as an external distractor that facilitated automatic processes to walk in anxiety-inducing settings. Participants were likely already dedicating cognitive resources to walk in anxiety-inducing settings, termed 'reinvestment' [12], supported by reporting identical levels of mental effort while walking at high elevation as while completing the DT at high elevation.

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Gait and speech rhythm abnormalities in early Parkinson's disease

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Citation

Růžička, E., Krupička, R., Vítečková, S., Tykalová, T., Novotný, M., Novák, J., Dušek, P., Rusz, J. Gait and speech rhythm abnormalities in early Parkinson's disease.

Introduction

Parkinson's disease (PD) is a progressive neurodegenerative synucleinopathy featuring a diverse spectrum of motor and nonmotor symptoms. Speech and gait are automatic motor activities that are especially affected in advanced stages of PD. Hypokinetic dysarthria in PD is manifested by various speech timing abnormalities, including rhythm deficiency prolonged pauses and altered speech rate. Gait impairment is mainly characterized by a slower velocity with shorter stride length and a compensatory increase in walking cadence. We aimed to investigate the presence and relationship of temporal speech and gait parameters that were not previously analyzed in patients with early untreated stage of PD.

Methods

Speech samples and instrumented walkway system assessments were acquired from a total of 60 de-novo PD patients (40 with tremor-dominant (TD) and 20 with postural instability/gait disorder (PIGD) subtype) and 40 matched healthy controls. Objective acoustic vocal assessment of seven distinct speech timing dimensions was related to instrumental gait measures including velocity, cadence, and stride length.

Results

Compared to controls, PIGD subtype showed greater consonant timing abnormalities by prolonged voice onset time (VOT) while also shorter stride length during both normal walking and dual task, while decreased velocity and cadence only during dual task [1]. Speaking rate was faster in PIGD than TD subtype. In PIGD subtype, prolonged VOT correlated with slower gait velocity ($r = -0.56$, $p = 0.01$) and shorter stride length ($r = -0.59$, $p = 0.008$) during normal walking, whereas relationships were also found between decreased cadence in dual task and irregular alternating motion rates ($r = -0.48$, $p = 0.04$) and prolonged pauses ($r = -0.50$, $p = 0.03$). No correlation between speech and gait was detected in TD subtype [1].

Conclusions

Our findings suggest that speech and gait rhythm disorder share similar underlying pathomechanisms specific for PIGD subtype.

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How relevant are anticipatory postural adjustments for gait initiation, gait and freezing of gait in Parkinson's disease?

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Introduction

Successful gait initiation requires simultaneous activation of motor and cognitive resources. During the preparation phase of gait initiation - the anticipatory postural adjustment (APA) - the first step is enabled through a combination of a medio-lateral shift of the center of pressure to unload the stepping leg and an anterior-posterior shift of the center of pressure to facilitate forward propulsion. Previous research found that APAs in people with Parkinson's disease (PD) can be smaller in size and longer in duration compared to healthy individuals, especially in individuals with freezing of gait [1]. However, the associations between APA size and other measures like first step characteristics, straight walking and freezing-related measures in people with PD have hardly been researched in studies to date. The aim of this work is to first investigate the mentioned associations at baseline, to explore the effects of a training intervention on those outcomes and to evaluate how changes in APA variables are associated with the changes in the other outcomes.

Methods

Gait initiation was assessed using inertial measurement units and was followed by subsequent straight walking measured via motion capture with reflective markers. A turning in place task was used to collect objective freezing of gait measures with wearable sensors. Assessments were conducted one week before (Pre), one week after (Post) and 4 weeks after (Follow-up) completion of a training intervention (participants were randomized to either split-belt treadmill training or regular treadmill training), each under single task (ST) and dual task (DT, auditory Stroop test) conditions. For the statistical analysis a linear mixed model was used to investigate the intervention effects and correlation analysis (Pearson correlation) to evaluate the associations between APA size and the other outcomes (first step characteristics, gait measures and freezing-related measures) for Pre and for the delta (Post-Pre).

Results

52 participants with PD (22 freezers) were assessed. We found that APA size in the medio-lateral direction was positively associated with gait speed and

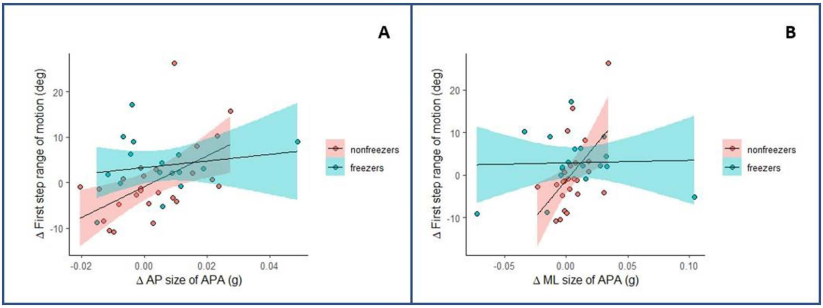

FIGURE 1
Association between training induced changes in **(A)** anterior-posterior (AP) and **(B)** medio-lateral (ML) size of APA and first step range of motion (ROM), respectively, for the dual task condition (DT). Correlations were only significant for nonfreezers (red).

stride length under DT condition at Pre, as well as negatively associated with objective freezing measure. The training was effective to improve first step range of motion, gait speed and stride length but effects were similar in the two training groups. For the associations between changes after the training (pooled sample) medio-lateral and anterior-posterior APA size showed a significant association with first step range of motion (DT) for the nonfreezers only (Fig. 1). The changes in APA size were not associated with changes in the gait and freezing-related measures.

Conclusions

The finding that APAs at baseline are associated with dual task gait characteristics and freezing measures in people with PD gives some new insights into the potential relevance of APAs. We could show that both treadmill interventions were effective in improving the first step during gait initiation but not the APA size. Nevertheless, the changes induced by the training were not modulated in the same way in freezers and nonfreezers, as an enlargement in APA size did only correlate with an increase in first step ROM in the nonfreezers during DT but not with any gait- or freezing-related change.

Thus, the findings indicate that the underlying mechanisms for APA generation are somewhat distinct from gait or the pathophysiological mechanisms underlying freezing of gait.

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Vertical center-of-mass braking and motor performance during gait initiation in young healthy adults, elderly and patients with Parkinson's disease: A comparison between force-plate and markerless motion capture system

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Citation
Simonet, A., Delafontaine, A., Fourcade, P., Yiou, E. Vertical center-of-mass braking and motor performance during gait initiation in young healthy adults, elderly and patients with Parkinson's disease: A comparison between force-plate and markerless motion capture system.

Introduction

Gait initiation (GI) is a locomotor task that is classically used in the literature to investigate stability control and motor performance (MP) in healthy subjects and neurological patients [1]. The quantification of these biomechanical parameters requires the recordings from force-plate(s) (FP) and/or motion capture system (MCS). Conventional MCS necessitate 38 markers to compute whole-body center of mass (CoM) kinematics. It is therefore time-consuming and, as FP, requires highly trained operators [2]. Markerless MCS is a recent innovative technology that facilitates motion analysis and that does not require any preparation of experimental participants. It may therefore drastically reduce the duration of experiments/data treatment, which may be relevant for researchers, clinicians and patients. This study questioned the ability of markerless MCS to evaluate accurately stability control and MP during GI in healthy subjects and patients with Parkinson's disease (PD). Values provided by FP were considered as the gold standards against which values provided by markerless MCS were compared.

Methods

Ten young healthy adults (YH), 10 healthy elderly (EH) and 10 PD patients participated in the study. All performed series of GI at a spontaneous and fast velocity. Signals from FP and markerless MCS were simultaneously recorded to compute CoM kinematics. Experimental variables were the peak of CoM velocity along the anteroposterior axis and the "braking index" (BI), which correspond to indicators of MP and stability control, respectively. BI was computed as the ratio [peak downward CoM velocity (VzMIN) minus vertical CoM velocity at foot-contact]/VzMIN. BI reflects the capacity of participants to brake their CoM fall under gravity [1]. To investigate the agreement between the two systems, a Bland and Altman (BA) analysis was conducted for both variables under each velocity condition and group. Repeated-measures ANOVA with the Velocity (spontaneous vs. fast) and System (FP vs. markerless MCS) as within-subject factors, and the Group (YH, EH, PD) as between-subject factor were carried out. Newman-Keuls post hoc tests were conducted when necessary.

Results

BA plots showed that the absolute and relative biases for MP and BI were virtually zero in each velocity condition and group. 95 % of the relative MP differences between the two systems ranged between +10 % and -10 % for MP and +40 % and -40 % for BI. ANOVA revealed a significant main effect of Group and Velocity (but not System) for both variables ($p<0.05$), and a Group*Velocity interaction. Post hoc tests further showed that the two systems detected similar significant differences between groups and velocity conditions for both variables.

Conclusions

These results suggest that markerless MCS are sufficiently accurate to compare BI and MP across groups and velocity conditions, which might be useful in a research and clinical context.

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Evaluation of postural sway in achilles tendinopathy patients following shock wave and ultrasound therapy

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Stania, M., Juras, G., Słomka, K.J., Marszałek, W., Król, P. Evaluation of postural sway in achilles tendinopathy patients following shock wave and ultrasound therapy.

Introduction
Achilles tendinopathy is a prevalent musculoskeletal disorder that affects 6 % of athletes [1]. Pain and oedema within the degenerative Achilles tendon as well as functional impairment and stiffness after prolonged rest, preclude vigorous physical activity and decrease patient's quality of life. Physical therapists and orthopedists continue to seek effective conservative treatments for Achilles tendinopathy. Physiotherapeutic treatment modalities include eccentric exercises, instrument-assisted soft tissue mobilization, low-level laser therapy, ultrasounds, and shock wave therapy [2]. The therapeutic efficacy of shock wave therapy and sonotherapy in patients with Achilles tendinopathy has so far been measured using subjective scales and questionnaires [3]. Therefore, the main objective of this randomized controlled study was to evaluate the efficacy of mechanotherapy in patients with non-insertional Achilles tendinopathy, using subjective evaluation of pain intensity and objective posturographic assessment of postural sway during quiet standing.

Methods

This randomized controlled trial is a part of the research project 'Objective and subjective assessment of the efficacy of radial shock wave therapy and sonotherapy in Achilles tendinopathy' which was prospectively registered in the Australian and New Zealand Clinical Trials Registry (no. ACTRN12617000860369; registration date: 9.06.2017). Thirty-nine patients with symptoms of pain of the mid-portion Achilles tendon over 3 months duration and tendon abnormalities identified on ultrasound were randomly allocated to one of three study groups: radial shock wave therapy (RSWT) group, ultrasound therapy (UD) group, and placebo ultrasound therapy (P-UD) group. Shock wave parameters were as follows: 2000 shocks (10 Hz, 3 bars) to Achilles tendon during the first phase of the session, another 2000 shocks (10 Hz, 3 bars) to the gastrocnemius muscle, one treatment session every 7 days (3 treatment sessions in total). UD patients received ultrasound frequency 3 MHz, ultrasound power density 1.0 W/cm^2, pulse ratio (duty cycle) 50 %, number of therapy sessions 10 (every day, five days a week). All ultrasound device parameters and therapy procedures in P-UD group were identical as in UD group except that the transducer did not generate sound waves. During the first two weeks of the therapy, all study groups have also undergone deep friction massage [4]. The activity-related pain intensity was assessed using the visual analogue scale (VAS). The postural sway assessment was carried out using two force plates (AMTI, AccuSway). The test (Platforms A and B) consisted of two 60-s quiet standing trials with each foot on a separate platform in two testing conditions: with eyes open and eyes closed. The values of the area (cm^2) and root mean square (rms, cm^2) of center of foot pressure (COP) in the antero-posterior and medio-lateral directions were calculated using the MATLAB software. Posturographic and subjective assessment of pain intensity was taken prior therapy and at 1, and 6 weeks of therapy completion. The Fisher's exact test was used for inter-group comparisons of nominal variables. The three-way repeated measures ANOVA with a 3 × 2 × 2 factorial design (timepoint × limb condition × vision) was used to analyze the posturographic parameters. The post-hoc comparisons were performed using the Bonferroni test.

Results

Subjective cure (percentage of patients stating that there was no pain according to VAS scale) was reported by 30.8 % of patients in RSWT group, 15.4 % in UD group and 7.7 % in P-UD group at week 6 post-therapy. Fisher's exact test revealed significantly more patients in RSWT group with decreased activity-related pain intensity ($p<0.03$). The three-way repeated measures ANOVA revealed an effect of eyes open/eyes closed conditions on rmsCOP in the antero-posterior and medio-lateral directions ($F_{(1,72)}=25.94$, $p<0.0001$; $F_{(1,72)}=11.13$, $p=0.002$, respectively). The Bonferroni post-hoc test showed that the means of those variables were significantly greater for quiet standing with eyes closed than with eyes open ($p<0.01$). Limb condition had an effect on the rmsCOP in the antero-posterior direction ($F_{(1,72)} = 6.15$; $p=0.02$) and area ($F_{(1,72)}=10.42$, $p=0.003$). The variables were significantly greater for the non-affected compared to affected limb ($p<0.05$). The three-way repeated measures ANOVA also demonstrated an effect of treatment type on rmsCOP in the medio-lateral direction ($F_{(2,72)}=4.74$, $p=0.01$) and area ($F_{(2,72)}=6.17$, $p<0.01$). Postural sway was significantly greater in patients in UD group than in RSWT group ($p<0.05$).

Conclusions

Radial shock wave therapy is more effective in pain reduction than sonotherapy in treating non-insertional Achilles tendinopathy. The static posturography may serve as useful tool for detecting postural control deficits in patients with Achilles tendinopathy. However, it is not suitable for monitoring the ongoing healing process of the affected Achilles tendon after mechanotherapy.

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Postural control after obstacle crossing during dual task conditions in children with developmental coordination disorder

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Introduction

Children with developmental coordination disorder (DCD) show difficulties with anticipatory planning and automatization of movement skill, prompting greater reliance on slower feedback-based control and compensatory strategies [1]. In everyday life, many situations require that movement and cognitive tasks are performed concurrently (dual task conditions). The aim of this study is to describe the effect of dual-tasking on the postural control during obstacle crossing in DCD and typically developing (TD) children.

Methods

133 children were recruited by age (7–8 years, 9–10 years, 11–12 years) and motor status (43 DCD and 90 TD children). All the children performed obstacle crossing while walking a 10-m walkway. At the walkway mid-point, participants were required to step over an adjustable obstacle (height standardized to 30 % of leg length), onto an embedded force plate (Kistler Instrumente, Winterthur, Switzerland) and then off in a continuous walking cycle to the end of the walkway. A secondary visual discrimination task (VDT) was presented via a data projector on the walkway, behind the obstacle, which required a verbal response. The VDT had two levels of difficulty: (a) simple/congruent: the child indicated the side of presentation of the stimulus (bunny or fox) by answering left or right; (b) complex/incongruent: the child verbalized the side opposite to that presented if the stimulus was a fox. Under dual-task conditions, the secondary cognitive task was triggered (pseudo-randomly) at the final heel strike before the obstacle. In total, four task conditions were evaluated: single task walking, no stimulus (but under dual-task instruction), simple dual-task, and complex dual-task. Sampling rate of force plate was 1000 Hz. Data was filtered by 4th order bidirectional low-pass Butterworth filter with the cut-off frequency of 20 Hz. Stance phase was determined as time interval in which vertical component of the ground reaction force exceeded 30 N. Output variables included minimum of ground reaction force in anterior-posterior direction during braking phase (braking peak, % body weight), maximum of ground reaction force in anterior-posterior direction during propulsion phase (propulsion peak, % of body weight), time of braking peak (% of stance time), time of propulsion

peak (% of stance time), range of movement of centre of pressure in anterior-posterior (COPAP, cm) and medial-lateral (COPML, cm) directions. Data from 4 trials per conditions (5 trials for single task conditions) were averaged. Normal data distribution was confirmed by Kolmogorov Smirnov test for all presented variables. For assessment of the effects of group, age and task condition, factorial ANOVA was used.

Results

In the braking phase, the age effect was significant on braking peak ($p<0.001$, $\eta^2 = 0.093$) and time of braking peak ($p=0.002$, $\eta^2 = 0.023$) indicating that older children had smaller and later braking peak. The group*task interaction was also significant ($p=0.002$, $\eta^2 = 0.024$, Fig. 1). In the propulsion phase, the interaction of age and motor group was significant on propulsion peak

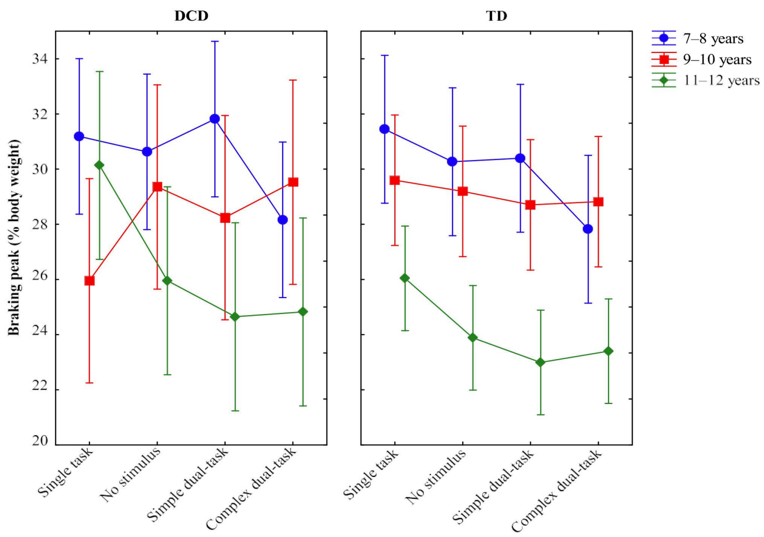

FIGURE 1
Braking peak in various groups and conditions.

($p<0.001$, $\eta^2 = 0.041$) and its time ($p=0.005$, $\eta^2 = 0.020$). In the TD group, older children showed smaller values of propulsion and earlier time of peak, while for DCD there was no clear tendency. For time of propulsion peak, the effect of motor group ($p=0.016$, $\eta^2 = 0.011$) and task ($p=0.016$, $\eta^2 = 0.020$) were significant, showing that for children with DCD, the propulsion peak occurred later. For COPML ($p<0.001$, $\eta^2 = 0.032$), the range of movement was larger in the DCD group compared with TD. For COPAP, the age ($p<0.001$, $\eta^2 = 0.092$) and age*group interaction effect ($p=0.002$, $\eta^2 = 0.023$) were significant. For TD, COPAP increased with age, while for DCD it increased for single task and no stimulus conditions, only.

Conclusions

Postural control during obstacle crossing is reduced in children with DCD compared with TD peers. The effect on postural control of a secondary cognitive task (presented at the point of stepover) was relatively small for both groups.

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Cortical activity during reactive balance reflect perceptual-motor and cognitive-motor interactions in health, aging, and disease

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Ting, L.H., Mirdamadi, J.L., Boebinger, S.E., Kerr, K.G., Palmer, J.A., Payne, A.M., Borich, M.R. Cortical activity during reactive balance reflect perceptual-motor and cognitive-motor interactions in health, aging, and disease.

Introduction
Engagement of cortical resources in balance control is an indicator of fall risk in older adults where people cannot “walk and talk” at the same

time [1,2], however, we do not understand how cortical activity affects the sensorimotor control of balance. There are many studies demonstrating changes in balance performance when a secondary cognitive or motor task is performed, particularly in balance-impaired individuals [3-6]. Increased cortical activity is also prevalent in older adults [5,7,8] but the mechanistic contributions to the control of balance are poorly understood. Recently, our lab and others have leveraged electroencephalography (EEG) recordings to identify cortical activity time-locked to reactive balance perturbations that are associated with individual differences across perceptual, cognitive, and motor domains in various healthy and balance-impaired groups. We also show evidence for cortically-mediated components of muscle activity for balance control, providing potential biomarkers and mechanisms of cortical control of balance.

Methods
We record 64 channel EEG, electromyography, kinetics, and kinematics during support-surface translations. We separated brain from non-brain sources using AMICA (Adaptive Mixture Independent Components Analysis) in eeglab software [9,10]. We focus primarily on two EEG metrics of cortical activity: 1) the timing and amplitude of the perturbation-evoked cortical N1 response, the first negative potential centered over the front-midline area (Cz) electrode, which is thought to reflect balance error-assessment, including anticipation, habituation, and fear [11], and 2) beta oscillatory power (13-30 Hz) of the N1 source, both before and after perturbations, an index of sensorimotor processing [12,13].

Results
Over several studies, we show that variability in cortical activity between individuals are stratified as a function perceptual, cognitive, and motor ability. Specifically, N1 amplitudes are greatest in young adults with poorer balance ability [14]. In older adults larger N1s are associated with lower balance confidence and with poor cognitive set-shifting, as well as greater evoked muscle coactivation [15]. N1 responses are delayed and reduced in individuals post-stroke and associated with clinical mobility scores as well

as asymmetric biomechanics of balance recover. Beta oscillations prior to perturbations are associated with perceptual ability in healthy young adults, and with balance ability in individuals with Parkinson's disease. Finally, we show that the cortical evoked activity likely drives later cortically-mediated muscle activity to augment ongoing subcortically-mediated balance-correcting muscle activity as balance challenge increases.

Conclusions
The intersections across perceptual, cognitive, and motor domains may help identify complex mechanisms underlying balance function. Our findings suggest that direct measures of hierarchical balance control mechanisms could enable development of mechanistic, precision-medicine efforts aimed at fall prevention.

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Can we maintain functional capacity and reduce the risk of chronic diseases in the elderly by regular exercise?

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Citation
Ukropcová, B. Can we maintain functional capacity and reduce the risk of chronic diseases in the elderly by regular exercise?

Ample evidence supports the irreplaceable role of regular physical exercise in the prevention and treatment of frailty and chronic diseases as well as in the maintenance of functional capacity and autonomy in the elderly. Both strength and endurance training are of importance, owing to their distinct capacity to stimulate muscle hypertrophy and aerobic fitness, respectively. In our previous work, we have shown that relatively short supervised aerobic-strength training with frequency 3x1 hour per week increases walking speed and improves aerobic fitness alongside cognitive functions and metabolism. These favorable changes can be maintained over the years by regular exercise, with frequency 2x1 hour weekly. Similarly, a 3-month supervised aerobic-strength training intervention effectively improved clinical state, balance, walking speed and other motor functions as well as a spectrum of metabolic and anthropometric parameters in patients with Parkinson's disease. Regular exercise was capable of inducing a physiological, albeit less pronounced response in skeletal muscle of patients with Parkinson's disease compared to controls. It can be concluded that exercise is effective and results in many health benefits that occur in parallel. Despite rich evidence-based medicine, exercise prescription aimed at increasing muscle mass and physical fitness across different patients' populations or in the elderly is still very limited. One of the great challenges for health care systems and for society is translation of evidence from research into clinical practice.

"PNP slows down" – Polyneuropathy as a model for gait disturbances leading to reduced gait speed

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Introduction

Gait disturbances are a common consequence of polyneuropathy (PNP) and significantly impact quality of life. In PNP, the distal nerves are damaged, mostly in a uniformly distributed pattern and the transmission of proprioceptive signals is disrupted [1,2]. More specifically, the proprioceptive signal contains velocity information based on changes in length (tendons or muscles) or joint angles, which is primarily important for accurate movement control [3-6] and postural stability [4]. The proprioceptive deficit in PNP often leads to deficits in postural stability which in turn manifests as balance problems [7-9], gait disturbances [10-12], and can lead to a higher risk of falling [10,13]. During walking, PNP patients show reduced gait speed [10], but less is known about the underlying mechanisms and the distribution of altered motor behavior across the whole body. This study aims to analyze whole body movements in a clinically relevant mobility test, i.e., the Timed Up and Go (TUG) test. We hypothesize that joint velocity curves across the whole body allow for a deeper understanding of PNP-related movement alterations. These findings may shed light on general motor control mechanisms responsible for the abnormal gait observed in PNP patients.

Methods

20 PNP patients (61±14 years) and a matched healthy control group (CG) performed TUG at i) preferred, and ii) fast movement speed, and iii) while counting backwards (dual-task). We calculated center of mass velocity (represents gait speed [cm/s]), joint velocities [cm/s] of 12 body segments (dominant/non-dominant side: ankle, knee, hip, shoulder, elbow, wrist) with respect to body coordinates during the walking sequence, and derived mean joint velocities and ratios between groups. Additionally, we applied the Performance Oriented Mobility Assessment, assessed fear of falling via the Falls Efficacy Scale – International questionnaire and asked for the maximum walking distance. For analyzing joint velocities, we used Statistical Parametric Mapping to evaluate and compare velocity curves of both groups.

Results

In a first analysis, we detected that PNP patients reduced their overall joint velocities with by roughly 13 %, on average, compared to CG group, irrespective of the individual joint velocity level, which is largely different e.g., between ankle and shoulder. Speed curves in individual joints as a function of the gait cycle showed significant differences between PNP and healthy CG. The significance levels of these differences varied across the time of the step cycle.

Conclusions

We found that PNP patients reduce all mean joint velocities during walking by a constant factor, when compared to CG. However, PNP patients maintain a similar relative velocity distribution across joints, compared to CG. The absolute velocity profiles of the joints across time differ between CG and PNP, as expected. Even though these differences are not evenly distributed throughout the step cycle, they do not seem to reach the significance level, when normalized by the mean average velocity. In general, we found that the main gait abnormality in PNP consists of a relative speed reduction in all joints, which may lead to the reduced gait speed. The individual amount of joint velocity reduction correlates well with clinical measures of the severity of functional impairments. We speculate that this speed reduction is a consequence of the impaired proprioceptive signal in PNP. Since all central gait control mechanisms should be intact in PNP, we claim that the gait disturbance of PNP patients is a model for a pure peripheral deficit. We deem it likely that gait impairments arising from centrally disturbed gait patterns such as e.g., in Parkinson's disease or normal pressure hydrocephalus may deviate from these strict rules, despite potentially exhibiting similar reductions in gait speed.

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Mechanisms underlying treatment effects of vestibular noise stimulation on postural instability in patients with bilateral vestibulopathy

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Citation
Wühr, M., Eder, J., Silvy, K., Tamara, A., Klaus, J. Mechanisms underlying treatment effects of vestibular noise stimulation on postural instability in patients with bilateral vestibulopathy.

Introduction
Previous studies indicate that imbalance in patients with bilateral vestibulopathy (BVP) may be reduced by treatment with low intensity noisy galvanic vestibular stimulation (nGVS). Here we examine the potential mechanisms underlying this therapeutic effect. In particular, we determined

whether nGVS-induced balance improvements in patients are compatible with stochastic resonance (SR) - a mechanism by which weak noise stimulation can paradoxically enhance sensory signal processing.

Methods

Effects of nGVS of varying intensities (0-0.7 mA) on body sway were examined in 19 patients with BVP standing with eye closed on a posturographic force plate. We assumed a bell-shaped response curve with maximal sway reductions at intermediate nGVS intensities to be indicative of SR. An established SR-curve model was fitted on individual patient outcomes and three experienced human raters had to judge whether responses to nGVS were consistent with the exhibition of SR.

Results

nGVS-induced reductions of body sway compatible with SR were found in 12 patients (63 %) with optimal improvements of 31±21 %. In 10 patients (53 %), nGVS-induced sway reductions exceeded the minimally important clinical difference (optimal improvement: 35±21 %), indicative of strong SR. This beneficial effect was more likely in patients with severe vestibular loss (i.e., lower video head impulse test gain; R=0.663; p=0.002) and considerable postural imbalance (baseline body sway; R=0.616; p=0.005).

Conclusions

More than half of the assessed patients showed robust improvements in postural balance compatible with SR when treated with nGVS. In particular patients with a higher burden of disease may benefit from the non-invasive and well-tolerated treatment with nGVS.

Effects of practicing boxing on postural stability in quiet upright stance

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Citation
Yordanova, Y., Pulev, T., Kirilova, K., Ruteva, M., Georgiev, G., Stambolieva, K. Effects of practicing boxing on postural stability in quiet upright stance.

Introduction

Box is a sport that requires a good and stable posture for ensuring a stable base for a good muscle-skeletal coordination for better and faster reactions and timely, strong and precise punches and body movement. The aim of this study was to evaluate if practicing boxing influences the postural stability by comparing boxers with different levels of expertise with untrained subjects in three positions during quiet upright stance.

Methods
This research included twenty boxers with different levels of expertise and 10 non-boxers who hadn't practiced box at all. The boxers were divided in two groups according to their sport experience in box: only practicing box for 1-3 years and boxers with more than 4 years of experience who had participated in boxing matches and even had won trophies. Postural sway was measured by a static posturographic system during quiet stance on firm support in six experimental conditions: three positions of the feet - side to side, normal position (feet at angle of 30 degrees, 3 cm between the heels), and feet at shoulder width, each performed with open and closed eyes. The duration of each trial was 30 s. The parameters that were used for evaluation of the changes in postural stability were total length of the displacements of the center of pressure (sway path), mean amplitudes and mean velocities of the postural sway in both medio-lateral (ML) and anterior-posterior (AP) directions.

Results
The untrained subjects had a longer sway path than the boxers in all experimental conditions. In all three groups, closing the eyes increased the sway path, but this effect diminished when the support area was increased. No significant differences were observed in the mean AP amplitudes between the three groups during stance with eyes open and there was a slight increase when the support area was diminished. When comparing the amplitudes of the postural sway in the three studied groups, it was found that more significant changes were observed in the AP direction compared to the ML, in which the results of the three groups were similar. The mean AP amplitudes of the untrained and intermediate boxers increased while standing with eyes closed, but such a trend was only subtle in the advanced boxers. The untrained subjects showed significantly higher velocities of the postural sway in both directions, compared to the two groups of boxers in all experimental conditions.

Conclusions
Compared to the untrained and intermediate boxers, the athletes with high sport experience showed more stable static balance under conditions with

evoked sensory conflict with eyes closed. In boxers with more than 4 years of sports experience, an increased role of the proprioceptive system in maintaining static balance was observed, compared to the untrained men and less trained boxers, in whom the role of the visual information is more prominent. We believe that this is due to developing motor habits related to the specific boxing technique. The changes in mean AP amplitudes and velocities of postural sway may serve as a sensitive indicator for the control process and evaluation of the effectiveness of the training process and progress, both for professionals and amateurs in boxing.

Evaluation of a new app-based, android mobile intervention for improving balance disorders among elderly in residential home care: A prospective pilot study

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Citation
Zur, O., Shimron, H.B.R., Deutsch, L. Evaluation of a new app-based, android mobile intervention for improving balance disorders among elderly in residential home care: A prospective pilot study.

Introduction

Falls are common among older people; however, sensory integration training can decrease this risk. As people become homebound, Tele-medicine and Tele-training have become essential alternatives. This pilot study evaluated the efficacy of the BBalance application (app), a new web-based, mobile balance rehabilitation program, in improving balance scores, increasing self-confidence and decreasing anxiety.

Methods
Forty-one residents of an assisted-living facility, ages 71-94 years, participated and were divided into intervention (n=28) and control (n=13) groups. All participants underwent the clinical Zur Balance Scale (ZBS) test for balance and completed self-confidence (Activities-Specific Balance Confidence) and general anxiety (Short Anxiety Screening test) questionnaires. The tests were conducted four months before the intervention (T1), at the beginning of intervention (baseline, T2) and at its end one month later (T3). The intervention group practiced twice daily using the BBalance app for one month. In addition, population between 25-90 years used the app last year.

Results
During T1–T2, ZBS scores between groups were similar (P=0.503). Between T2 and T3, ZBS scores in the intervention group improved compared to controls (P<0.0001). Self-confidence and anxiety showed a trend toward improvement. Information among the other population will be added as well.

Conclusions
After using the BBalance app twice daily for one month, balance scores improved. Anxiety and self-confidence demonstrated a trend toward improvement. The BBalance app can be a useful tool for balance rehabilitation when Tele-health is required in different ages.

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