Investigating changes in real-time conscious postural processing by older adults during different stance positions using electroencephalography coherence

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Abstract

Background/Study Context. Adjustments of posture in response to balance challenges may lead to subsequent increases in conscious posture processing. If cognitive resources are stretched by conscious processing of postural responses fewer resources will be available to attend to environmental trip or fall hazards. The objective of the study was to explore brain activity related to conscious processing of posture as a function of movement specific reinvestment and fear of falling.

Method. Forty-three older adults (M = 71.4, SD = 4.1) stood with a wide or narrow stance on a force-plate while neural coherence between verbal-analytical (T3) and motor planning (Fz) regions of the brain was assessed using electroencephalography. Propensity for movement specific reinvestment was assessed using the Chinese version Movement Specific Reinvestment Scale (MSRS-C) and fear of falling was assessed using the Chinese version Fall Efficacy Scale International (FES-I[CH]).

Results. Scores from the MSRS-C were negatively correlated with changes in T3-Fz coherence that occurred when participants shifted from wide to narrow stance. Together, MSRS-C and FES-I(CH) uniquely predicted the percentage change in T3-Fz coherence between the two stance conditions.

Conclusion. Presented with two postural tasks of different complexity, participants with a lower propensity for conscious control of their movements (movement specific reinvestment) exhibited larger changes in real-time brain activity (neural coherence) associated with conscious postural processing.

Keywords: Postural control; Conscious processing; Falls; Electroencephalography (EEG); Movement specific reinvestment

Introduction

Maintaining efficient postural control is important as people age, particularly if they wish to avoid falling. Globally, falls are the second leading cause of death, with most fatalities occurring in older adults aged over 65 years (World Health Organization, 2018). Although it seems that little cognitive effort is required to maintain postural control, a growing number of studies suggest that regulating posture is not solely automatic, and that higher-level conscious (attention) processes are involved (see reviews by Maki & McIlroy, 2007; Woollacott & Shumway-Cook, 2002; Yogev-Seligmann, Hausdorff, & Giladi, 2008).

To investigate conscious processing during postural control, many studies have used behavioral approaches, such as dual-task paradigms, to divide cognitive resources (e.g., between the conscious processing of sensorimotor inputs and the cognitive tasks) (Huxhold, Li, Schnmiedek, & Lindenberger, 2006). Typically, in these studies, stability during standing or walking has been examined when participants also perform secondary tasks, such as mental arithmetic, spatial memory or auditory probe reaction responses. In older adults, priority is usually stability rather than performance of a secondary cognitive task (Brauer, Woollacott, & Shumway-Cook, 2002; Brown, Shumway-Cook, & Woollacott, 1999; Brown, Sleik, Polych, & Gage, 2002; Lajoie, Teasdale, Bard, & Fleury, 1996; Lindenberger, Marsiske, & Baltes, 2000; Rankin, Woollacott, Shumway-Cook, & Brown, 2000). However, when older adults are explicitly instructed to prioritize a secondary task (e.g., talking), performance of the primary task is typically compromised (e.g., walking) (Verghese et al., 2007). From a safety perspective, prioritizing stability reduces the likelihood of falling (Yogev-Seligmann, Hausdorff, & Giladi, 2012). However, prioritizing stability is not always feasible in a community setting if simultaneous tasks are important, such as responding appropriately to pedestrian signals when crossing the street (Brauer et al., 2002).

Older adults who consciously process their posture may thus be more vulnerable to compromised performance, because their cognitive resources are more stretched by secondary tasks. Masters (1992; see also Masters, Polman, & Hammond, 1993) suggested that the tendency to consciously process movement is associated with personality and, therefore, is subject to individual differences. Consistent with this argument, Masters et al. (1993) showed that people with a greater propensity to consciously process their movements were more likely to display disrupted performance under psychological pressure. Well-learned (familiar) movements tend to be executed with great efficiency (both cognitive and physical) as non-conscious procedures (Anderson, 1982). However, restoration of conscious processes to control the movements, originally described by Masters et al. (1993) as reinvestment, can disrupt their efficiency (Masters & Maxwell, 2008; see McNevin, Shea, & Wulf, 2003 for a similar arguement related to the constrained action hypothesis). A general Reinvestment Scale (Masters et al., 1993) and a more specific Movement Specific Reinvestment Scale (MSRS; Masters, Eves, & Maxwell, 2005) were developed as measures of the propensity for conscious processing of movements (see also Kal et al., 2016; Kal et al., 2014; Kleynen et al., 2013; Laborde, Dosseville, & Kinrade, 2014; Laborde et al., 2015 for the MSRS in the Dutch, French, and German speaking populations). The MSRS is a 10-item self-report questionnaire that is now commonly used. The Scale is comprised of two factors, conscious motor processing (CMP) and movement self-consciousness (MSC). Questions related to conscious motor processing, such as “I reflect about my movement a lot”, are thought to assess explicit control of movements, whereas, questions related to movement self-consciousness, such as “I am self-conscious about the way I look when I am moving”, are thought to assess concerns about moving as a social object (Masters et al., 2005). In their study, Masters et al. (2005) showed the MSRS to have acceptable test-retest reliability (MSC; $r = .67$, $p < .01$ and CMP; $r = .76$, $p < .01$) and internal reliability (MSC; Cronbach’s alpha =

.78 and CMP; Cronbach's alpha = .71). Scores from the Chinese version of the MSRS (MSRS-C; Masters et al., 2005; Wong, Masters, Maxwell, & Abernethy, 2008) suggest that older fallers tend to have a higher propensity for movement specific reinvestment than older non-fallers (but see de Melker Worms, Stins, van Wegen, Loram, & Beek, 2017, who found evidence neither for nor against higher MSRS in older fallers). It is unclear, however, whether this propensity is a pre-fall characteristic that raises the chances of falling or a post-fall strategy to reduce the chances of further falls (Wong et al., 2008) Score on the MSRS has also been shown to positively correlate with the number of years since diagnosis of Parkinson's disease (Masters, Pall, MacMahon, & Eves, 2007). For people with PD, it appears that over time the propensity to consciously process their movements increases (Masters et al., 2007). In other studies, the propensity for conscious processing was also associated with the onset of movement impairments, such as in stroke (Kal et al., 2016; Orrell, Masters, & Eves, 2009) or in those with knee pain (Selfe et al., 2014). Similarly, compared to younger patients who had undergone unilateral total knee replacement, older patients reported greater propensity for movement specific reinvestment, possibly due to the debilitating pain and loss of function caused by knee osteoarthritis (Street, Adkin, & Gage, 2018). Additionally, threat of falling has been shown to cause increased state MSRS in young people (Huffman, Horslen, Carpenter, & Adkin, 2009), and even physical therapists who specialize in training or retraining movement have been shown to score higher on the MSRS than other rehabilitation and non-health professionals (Capio, Uiga, Malhotra, Eguia, & Masters, 2018).

Despite the capacity of the MSRS to discriminate between healthy individuals and those with movement impairments, it initially was designed as a trait measure rather than as a state measure. Although state versions have been used to investigate conscious processing in different contexts (Huffman et al., 2009; Zaback, Cleworth, Carpenter, & Adkin, 2015), the assessment relies solely on self-report and cannot, therefore, take place during task execution to measure real-time conscious processing (movement specific reinvestment).

In recent years, electroencephalography (EEG) has been employed to measure neural co-activation (coherence) as an objective measure of conscious processing during motor performance. EEG can record cortical activity under naturalistic conditions in which the action is usually performed and has faster temporal resolution than other methods used to examine brain activity, such as the functional magnetic resonance imaging (fMRI; Crosson et al., 2010). Of various EEG frequency bands, the alpha band has been one of the most widely studied (Crews & Landers, 1993). The alpha band has been found to correlate with cognitive functions (Klimesch, 1999), with the fast alpha band (generally 10-12 Hz) reflecting task-specific attention and visual-motor processing (Babiloni et al., 2004) and the slow alpha band (generally 8–10 Hz) reflecting general attention processing (Kerick et al., 2001).

Previous studies using EEG suggested that conscious processing during motor performance is associated with coherence between the verbal-analytical (T3)[1] and motor planning (Fz) regions of the brain (Chow, Ellmers, Mak, Young, & Wong, 2019; Chu & Wong, 2018; Deeny, Hillman, Janelle, & Hatfield, 2003; Gallicchio, Cooke, & Ring, 2016; Hatfield, Landers, & Ray, 1984; van Dujin, Buszard, Hoskens, & Masters, 2017; Zhu, Poolton, Wilson, Maxwell, & Masters, 2011; but see Bellomo, Cooke, & Hardy, 2018, who found power to be more sensitive to verbal analytical processing than coherence). High coherence implies highly synchronized communication between two regions, with low coherence indicating the opposite (Weiss & Mueller, 2003). Deeny et al. (2003) therefore interpreted lower T3-Fz coherence in expert shooters compared to unskilled shooters, as a reflection of low verbal-analytical involvement in the task, a characteristic traditionally associated with performance by experts (e.g., automaticity). In related work, Zhu et al. (2011) showed that amongst novices, those who scored high on the MSRS displayed higher

T3-Fz coherence when golf-putting than those who scored low on the MSRS. The authors suggested that this finding provided the first objective neural evidence for reinvestment (Zhu, Poolton, Wilson, Maxwell, et al., 2011). In the same study (Experiment 2), the authors extended the use of T3-Fz coherence to provide neural evidence of implicit motor learning. Novices who learned golf-putting implicitly (with low verbal analytical engagement in performance) displayed lower T3-Fz coherence than novices who acquired the skill explicitly (with high verbal analytical engagement). Outside the sport domain, Zhu and his colleagues (2011) showed novices who acquired a laparoscopy skill implicitly displayed lower T3-Fz coherence than novices who did so explicitly.

Existing literature has examined the association between propensity for reinvestment and postural modifications under threat or cognitive load manipulations (dual-tasking). Huffman et al. (2009), for example, found that conscious control of posture (assessed using a state measure of the Movement Reinvestment Scale) was greater when people balanced at an elevated height compared to ground level height; presumably, in response to fear of falling. Similarly, Zaback et al. (2015) found that people with a greater general propensity for conscious control of their movements (assessed using the trait measure of the Movement Specific Reinvestment Scale) swayed more at an elevated height. Uiga et al. (2018) showed that under single task conditions, those with a greater propensity for movement specific reinvestment had greater sway and a more constrained manner of postural control in the medial-lateral direction.

With regard to using T3-Fz coherence as an objective measure of conscious engagement in postural control, Ellmers et al. (2016) demonstrated greater T3-Fz coherence when young adults were instructed to focus internally in order to consciously control their sway, compared to instructions to focus externally or no instructions. Chu and Wong (2018) asked participants to adopt different stances on a foam surface. They found a trend for perceptions of increased balance difficulty (caused by decreased base of support) to be associated with greater T3-Fz coherence in participants who scored high on the MSRS (high reinvestors) compared to those who scored low on the MSRS (low reinvestors). However, the authors acknowledged that a limitation of their study was the lack of objective measurement of postural performance (i.e., sway measurements). In a more recent study of young and older adults, Chow et al. (2019) investigated body sway and its association with T3-Fz coherence and showed that compared to baseline, focusing internally on the lower limbs resulted in increased T3-Fz coherence and sway. However, this finding was limited to young adults. Chow et al. (2019) also examined the association between MSRS and T3-Fz coherence during a baseline standing task; however, no relationship was found.

Neither Chu and Wong (2018) nor Chow et al. (2019) found a statistically significant relationship between MSRS score and T3-Fz coherence. MSRS is a general psychometric trait measure and, therefore, might not specifically reflect the extent to which conscious postural processing occurs during standing (Uiga et al., 2018; Wong, Abernethy, & Masters, 2016). In addition, both studies required participants to stand on a foam surface, which lacks ecological validity, given that older adults are unlikely to ever need to maintain their posture on such a surface. Therefore, in this study, we examined changes in the association between MSRS and T3-Fz coherence when older people performed a simple balance task (wide stance) and a more complex balance task (narrow stance) on firm ground. We included a measure of fall efficacy, given that fear of falling plays a significant psychological role in balance and locomotion of older people (Tinetti, Richman, & Powell, 1990), and given that movement specific reinvestment has been show to occur in situations that are stressful ((Masters & Maxwell, 2008; Masters et al., 1993). We hypothesized that fear of falling and a greater propensity for movement specific reinvestment would be associated with higher T3-Fz coherence when shifting from wide to narrow stance.

Method

Participants

Forty-four[2] older adults (*M* = 71.3 years, *SD* = 4.1 years) were recruited by convenience sampling from the local community. However, only 43 older adults (*M* = 71.4 years, *SD* = 4.1; 38 females and 5 males) were included in the data analysis (please see Data Analysis section). Inclusion criteria were (a) aged 65 years and above, (b) able to understand and provide consent, (c) able to walk independently indoors. Participants were excluded if they (a) had a history of cerebrovascular disease, Parkinson's disease or any other neurological impairment or (b) scored less than 24 on the Cantonese version of the Mini-Mental State Examination (CMMSE; Chiu, Lee, Chung, & Kwong, 1994; Folstein, Folstein, & McHugh, 1975). The study was reviewed and approved by the institutional ethics board and all participants consented to participate.

Tasks and Procedure

Participants who met the criteria were invited to stand on a force-plate without shoes for 15s to allow familiarization. They stood in a self-selected comfortable posture with arms to the sides and eyes looking straight ahead at the wall. Functional balance ability was then assessed by taking the average of two Timed Up and Go trials (TUG; Mathias, Nayak, & Isaacs, 1986; Podsiadlo & Richardson, 1991) followed by the Berg Balance Scale (BBS; Berg, Wood-Dauphinée, Williams, & Gayton, 1989).

Next, participants were fitted with EEG electrodes and were asked to stand on the force-plate without shoes, using one of two stances (randomized between participants). They were required to look straight ahead with their arms at the sides. Each stance was performed twice to obtain an average measurement. For each stance, EEG activity measurements were recorded 5s before the force-plate commenced recording for 15s. The first 5s of cortical activity were not included in the analysis to eliminate any possible initial artifacts.

In one of the two stance tasks, participants were asked to stand on the force-plate with their feet positioned comfortably, approximately shoulder width apart (wide stance). In the other stance task, the feet were placed together side by side so that they touched each other (narrow stance).

After testing, EEG electrodes were removed, and participants' fear of falling was assessed using the Chinese version Fall Efficacy Scale International (FES-I[CH]; Kwan, Tsang, Close, & Lord, 2013; Tinetti et al., 1990; Yardley et al., 2005). Finally, the Chinese version of the Movement Specific Reinvestment Scale was administered (MSRS-C; Masters et al., 2005; Wong et al., 2008; Wong, Masters, Maxwell, & Abernethy, 2009).

Apparatus

A 69 x 40 x 2.5 cm (L x W x H) Zebris FDM-S multifunctional force-plate (Zebris Medial GmbH, Germany) with sampling frequency of 50 Hz was positioned 55 cm away from a blank wall. Center of pressure (COP) path length (mm) and mean sway velocity (mm/sec) were recorded with WinFDM-S v.1.2.9 (Zebris Medical GmbH, Germany).

Electroencephalographic (EEG) activity was measured using a wireless EEG device (Brainquiry PET 4.0, Brainquiry, The Netherlands) at a sample rate of 200 Hz and recorded using real-time biophysical data acquisition software (BioExplorer 1.5, CyberEvolution, US). The raw signals were filtered through a low pass filter (42 Hz) and a high pass filter (2Hz) to remove potential biological artifacts and noise. Prior to each measurement, an impedance test was conducted using a 48-52 Hz filter with threshold set at 20 microvolts. Cortical activity was measured using disposable 24mm electrodes positioned at 3 scalp locations (Fz, T3, and T4) in accordance with the standard international 10-20 system (Jasper, 1958) and referenced to the right mastoid and grounded to the left mastoid (see Chow et al., 2019; Ellmers et al., 2016). One electrode was placed below the left eye to record eye blink. Custom scripts from biophysical data processing and analysis software (BioReviewer 1.5, CyberEvolution, US) were used to pre-process the EEG data and in-house algorithms were used to calculate T3-Fz and T4-Fz coherence in 1-Hz frequency bins (Zhu, Poolton, Wilson, Maxwell, et al., 2011). T4-Fz coherence was measured to ensure co-activation from the visual spatial and motor planning regions were a function of specific left temporal and frontal regions of the brain and not a global cortical phenomenon (Zhu, Poolton, Wilson, Hu, et al., 2011)

Data Analysis

Paired sample t-tests were used to examine differences between sway (COP path length, mean sway velocity) during wide and narrow stance. Percentage change in T3-Fz and T4-Fz EEG coherence estimates in the fast alpha frequency range (10-12 Hz) were calculated as follows:

$$Percentage\ change = \frac{Narrow\ stance\ coherence - Wide\ stance\ coherence}{Wide\ stance\ coherence}\ x\ 100\%$$

The relationships between the Chinese version of the Movement Specific Reinvestment Scale (MSRS-C) and the Chinese version of the Fall Efficacy Scale International (FES-I[CH]), together with the percentage change in T3-Fz and also in T4-Fz coherence, were explored. Pearson’s correlation was used for parametric data and the Spearman’s Rho was used for non-parametric data. Further analysis was conducted by hierarchical multiple regression analysis, first controlling for age, gender and score on the Cantonese version of the Mini-Mental State Examination (CMMSE), then entering MSRS-C and FES-I(CH) as independent variables to predict percentage change in coherence. One participant was removed from the analysis as the change in T3-Fz coherence was extreme. This was based on a box plot and visual examination of a standard scatter plot.

Results

Individual Characteristics

Individual characteristics, including age, COP sway measurements, CMMSE, TUG and BBS scores, as well as MSRS-C and FES-I(CH) scores, are summarized in Table 1 and Table 2.

Table 1 and Table 2 here

Postural Sway

Path length was greater during narrow stance (*M* = 173.10, *SD* = 36.59) than wide stance (*M* = 76.82, *SD* = 28.09). A paired samples t-test revealed that the difference was statistically meaningful, $t(42) = -18.03$, $p < .001$. Mean sway velocity was also statistically greater during narrow stance (*M* = 11.76, *SD* = 2.49) than wide stance (*M* = 5.21, *SD* = 1.91), $t(42) = -17.99$, $p < .001$.

Correlation and regression analysis

MSRS-C scores were negatively correlated with change in T3-Fz coherence ($r[41] = -.34$, $p = .026$) (see Table 3). Higher MSRS-C scores were associated with less change in T3-Fz coherence when participants shifted from wide to narrow base. For FES-I(CH) scores, which were not normally distributed, Spearman's Rho correlations revealed a positive correlation with MSRS-C ($r[41] = .39$, $p = .009$), but not with change in T3-Fz coherence ($p = .877$) (see Table 4). Specifically, greater fear of falling, assessed by the FES-I(CH), was associated with higher MSRS-C score. Statistically meaningful correlations were not evident between change in T4-Fz coherence and scores on the MSRS-C or the FES-I(CH) (p's > .05).

Table 3 and Table 4 here

Hierarchical multiple regression revealed that when age, gender and CMMSE score were accounted for, MSRS-C and FES-I(CH) scores were responsible for 27.1% (unadjusted R^2) and 17.2% (adjusted R^2) of the variance in change in T3-Fz coherence from wide to narrow stance, $F(5, 37) = 2.75$, $p = .033$ (see Table 5).

No correlations were evident for change in T4-Fz coherence between wide and narrow stance, so we did not conduct further hierarchical multiple regression analysis.

Table 5 here

Discussion

Our force-plate data suggested that a narrow stance caused more sway than a wide stance. This is consistent with previous research showing that standing with a narrow stance (feet together) produced greater center of pressure displacements than other stance widths (Kirby, Price, & MacLeod, 1987) and produced larger sway amplitudes (Mitra & Fraizer, 2004). During narrow stance, there is constant weight shifting from one leg to the other, whereas during more stable (wider) stances, posture maintenance is relatively passive and requires less cognitive control (Henry, Fung, & Horak, 2001).

Scores from the Chinese version of the Movement Specific Reinvestment Scale (MSRS-C) were related to scores from the Chinese version Fall Efficacy Scale International (FES-I[CH]). This is not surprising, as older adult fallers report a greater tendency to monitor and control their movements mechanics as a way to prevent future falls (Wong et al., 2008; but see Ellmers, Cocks, & Young, 2019, who found evidence that in both low and high threat situations, older adult fallers report comparable number of movement processing statements as non-fallers).

Scores on the MSRS, together with fear of falling, predicted changes in T3-Fz coherence when participants adopted different stances (wide versus narrow). Specifically, for those with higher scores on the scale (a greater propensity for conscious monitoring and control of their movements), reduction in the base of support (which led to more sway) did not change communication (coherence) between the T3- and Fz regions of the brain (verbal-analytical/motor planning), suggesting no change in the extent to which posture was consciously processed. On the other hand, for those with lower scores (a lesser propensity to consciously monitor and control their movements), reduction in the base of support (narrow stance) triggered increased T3-Fz communication, suggesting that real-time conscious postural processing escalated. These findings are in conflict with our hypothesis that a high propensity for movement specific reinvestment would result in a greater increase in T3-Fz coherence when changing from a wide stance to a narrow stance. The findings, therefore, are not consistent with the trend reported by Chu and Wong (2018) for high reinvestors to display a sharper increase in conscious postural processing than low reinvestors as stance complexity increased. Our results may differ from Chu and Wong's (2018) study because in our study participants stood on firm ground rather than foam. Standing on different surfaces might affect the way older adults consciously process their posture. When base of support decreases on firm ground, it may be that low reinvestors need to utilize more conscious postural processing than usual, which might cause greater disruption of postural automaticity. As a consequence, low reinvestors would be less able to attend to environmental fall hazards because their cognitive resources are stretched.

Our investigation into MSRS-C together with FES-I(CH) and changes in EEG visual-spatial and motor processing (T4-Fz coherence) of movements did not reveal a relationship between the variables. Movement specific reinvestment refers to a propensity to use declarative knowledge to control movements (Masters & Maxwell, 2008), so perhaps it is not surprising that the relationship is more obvious for the verbal-analytical (T3) region of the brain than the visuo-spatial (T4) regions. Previous studies have revealed a similar pattern of results (Chu & Wong, 2018; Gallicchio et al., 2016; Zhu, Poolton, Wilson, Hu, et al., 2011; Zhu, Poolton, Wilson, Maxwell, et al., 2011). Therefore, the capacity of MSRS scores to predict changes in T3-Fz and not T4-Fz coherence suggests that co-activation between verbal-analytical and motor planning regions was influenced by local rather than global cortical activity (Zhu, Poolton, Wilson, Hu, et al., 2011).

We acknowledge that there are limitations to this study. First, our participants were community dwelling older adults with relatively high functional balance ability (as shown by the Berg Balance Scale scores) and might not be representative of the wider population of community-dwelling older adults. Second, our results are limited to static standing. Therefore, the current results do not necessarily translate to more dynamic tasks typical of daily activities carried out by older adults. Third, we treated movement specific reinvestment as a single dimensional trait; however, it has been suggested that the MSRS subscales, CMP (conscious motor processing) and MSC (movement self-consciousness) are distinct constructs and influence performance behavior in different ways (Malhotra, Poolton, Wilson, Fan, & Masters, 2014; Malhotra, Poolton, Wilson, Leung, et al., 2015; Malhotra, Poolton, Wilson, Omuro, & Masters, 2015; van Ginneken et al., 2017; Zaback et al., 2015). Future studies could further investigate the individual influence the two subscales might have on changes in conscious postural processing and extend investigation to older adults with poorer balance as they perform more complex dynamic tasks. Fourth, the majority of our participants were females. As such, we were unable to further explore possible gender differences in our results.

To our knowledge, this study represents the first attempt to relate movement specific reinvestment and fall efficacy to changes in conscious posture processing between postural tasks differing in complexity. By utilizing T3-Fz coherence as an objective, neurophysiological measure of movement specific reinvestment, we reveal that older adults with a low propensity for movement specific reinvestment are more likely to display increased conscious postural processing when their balance is challenged to a greater extent.

Funding

The work described in this article was supported by a grant (Early Career Scheme) from the Research Grants Council of the Hong Kong Special Administrative Region, China [Grant number 27608815]. The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Acknowledgments

The authors are grateful to Dr Liis Uiga for her insights, the staff at Chung Hok Social Centre for the Elderly for their assistance in participant recruitment, and the participants who took part in the study.

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Footnotes

[1]Papers by Bellomo, Cooke, and Hardy (2018) Gallicchio, Cooke, and Ring (2016), and van Dujin, Buszard, Hoskens, and Masters (2017) used the term T7 and T8 from the newer EEG recording systems to denote the same electrode position as T3 and T4 (respectively) from the older EEG recording systems.

[2]Thirty-three participants also completed a 20s tandem stance task (with and without holding a tray of water, randomized order). However, some participants placed one foot diagonally ahead of the other and did not perform a true tandem stance (placing one foot directly in front of the other, heel-to-toe), even though they were able to do so for 30s during the Berg Balance Scale assessment. This may have confounded the sway and T3-Fz coherence measures, so the data were excluded from analysis.

Table 1

Mean values and standard deviations for parametric dependent variables (N = 43).

	M	*SD*
Path length: Wide stance (mm)	76.82	28.09
Path length: Narrow stance (mm)	173.10	36.59
Mean velocity: Wide stance (mm/sec)	5.21	1.91
Mean velocity: Narrow stance (mm/sec)	11.76	2.49
MSRS-C	29.09	12.77

Note. MSRS-C = Chinese version of the Movement Specific Reinvestment Scale.

Table 2

Median values and interquartile range for non-parametric dependent variables (N = 43).

	Mdn	*IQR*
Age	70.00	7.00
CMMSE	29.00	2.00
TUG (sec)	10.52	1.82
BBS	56.00	1.00
FES-I(CH)	29.00	12.00

Note. CMMSE = Cantonese version of the Mini-Mental State Examination; TUG = Timed Up and Go; BBS = Berg Balance Scale; FES-I(CH) = Chinese version Fall Efficacy Scale International.

Table 3

Descriptive Statistics and Pearson Correlation Matrix for MSRS-C Scores and Percentage Change in T3-Fz Coherence.

	M	*SD*	1
1. MSRS-C score	29.09	12.77	—
2. Change in T3-Fz coherence (%)	0.228	0.459	-.339*

Note. MSRS-C = Chinese version of the Movement Specific Reinvestment Scale.

* $p < .05$.

Table 4

Descriptive Statistics and Spearman Rho Correlation Matrix for Scores From MSRS-C, FES-I(CH), and Percentage Change in T3-Fz Coherence.

	Mdn	*IQR*	1	2
1. MSRS-C	31.00	21.00	—	—
2. FES-I(CH)	29.00	12.00	.391**	—
3. Change in T3-Fz coherence (%)	0.188	0.626	-.365*	.024

Note. MSRS-C = Chinese version of the Movement Specific Reinvestment Scale; FES-I(CH) = Chinese version Fall Efficacy Scale International

* $p < .05$. ** $p < .01$.

Table 5

Hierarchical Multiple Regression Analysis Summary for Percentage Change in T3-Fz Coherence

	Percentage change in T3-Fz coherence			
	Model 1		Model 2	
Variable	B	β	B	β
Constant	-.002		1.679	
Age	.018	.161	.016	.145
Gender	.320	.226	.351	.248
CMMSE	-.046	-.130	-.105	-.293
MSRS-C			-.017**	-.485
FES-I(CH)			.021*	.391
R^2	.085		.271	
F	1.206		2.745*	
ΔR^2	.085		.186	
ΔF	1.206		4.710*	

Note. CMMSE = Cantonese version of the Mini-Mental State Examination; MSRS-C = Chinese version of the Movement Specific Reinvestment Scale; FES-I(CH) = Chinese Version Fall Efficacy Scale International.

*$p < .05$. **$p < .01$.