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Short communication

Postural instructions affect postural sway in young adults

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A B S T R A C T

Background: Instructions to exert effort to correct one's posture are ubiquitous, but previous work indicates that effort-based postural instructions can impair balance control in older adults with and without neurodegenerative disease. Although less-studied, young adults are at high risk of injurious falls.

Research question: How do different postural instructions influence static balance in young adults?

Methods: Single-session, counterbalanced, within-subjects design. Twenty young adults briefly practiced three different ways of thinking about their posture, then attempted to employ each way of thinking while standing on springy foam for 30 s with eyes open. *Relax* instructions were used as a baseline between experimental conditions. *Effort-based* instructions emulated popular concepts of posture correction using muscular exertion. *Light* instructions aimed at encouraging length and width while reducing excess tension. Postural sway was assessed with an inertial sensor at the low back.

Results: Effort-based postural instructions increased path length and jerk of postural sway during quiet stance, relative to Light and Relaxed instructions.

Significance: These results are consistent with previous work in older adults indicating that thinking of upright posture as inherently effortful impairs balance. Therefore, the common practice of instructing young adults to use effortful posture may impair their balance performance.

1. Introduction

"Lift your head! Suck in your stomach! Stand up straight! Pull your shoulders back!" Advice along these lines is common in dance and exercise classes, in physical therapy and chiropractic offices, in gyms, and online [1–5]. However, recent evidence suggests that these kinds of exhortations to exert effort toward upright posture may not, in fact, be beneficial for balance or movement control. We recently demonstrated that thinking about pulling oneself up to one's greatest height can lead to excessive muscle activation and reduced static and dynamic balance control, both in people with Parkinson's disease and in healthy older adults [6,7]. The present study extends this investigation to healthy young adults.

Standing balance is typically assessed by examining postural sway, with larger, faster, or jerkier sway indicating less steadiness and less precise control of balance [8,9]. In the present study, we asked healthy young adults to stand naturally on an unstable surface with three different postural instructions: effort-based, relaxed, and light. Effort-based postural instructions were designed to emulate those often given by health-care and exercise professionals, whereas Light instructions were based on a postural approach called Alexander technique, which aims to improve dynamic postural tone without exerting undue effort [10–13]. We measured postural sway with an inertial sensor, and we predicted that postural sway would be larger and jerkier in the effort-based instructional condition than in the other conditions, consistent with results seen in other subject populations.

2. Methods

2.1. Subjects

We recruited 20 subjects (16 female and 4 male, aged 18–29 years) through the University of Idaho's psychology experiment sign-up system. This is the same number of subjects as were used to test the approach in healthy older people and people with Parkinson's disease [6,7]. All subjects reported normal vision and hearing; none reported psychiatric or neurological disorders, recent concussions, acute musculoskeletal injury, balance impairments, or current medications that could affect balance. Consent was obtained via a form approved by the University of Idaho's Institutional Review Board.

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2.2. Protocol

We used a within-subjects design. Before the trials, subjects practiced standing with each set of postural instructions, shown in Table 1. During practice, subjects alternated among the Relaxed (R), Effort-based (E), and Light (L) conditions until they and the experimenter were confident that the subjects understood the instructions and could implement them easily. The total practice time was less than 5 min. The R condition was used as a baseline condition. Half the subjects implemented the instructions in R-L-R-E order, the other half used R-E-R-L order. Thus, there were four blocks, and the conditions of primary interest always followed the baseline. Only the second baseline block was analyzed. Afterwards, the experimenter asked the subjects whether they were uncomfortable in any condition.

To measure postural sway, we used a validated research protocol [14] called iSWAY (APDM, Portland, OR). During the trials, subjects stood without shoes on a 10-cm thick Airex ® foam pad, with an APDM Opal wireless inertial sensor attached to their lumbar spines by a wide elastic belt [15]. Stance width was standardized with APDM's template to 20 cm, and arms were crossed in front of the chest. Subjects were asked to stand naturally and look straight ahead at a poster 3 m away. All subjects completed three 30-second trials in each of the blocks as described above. Between trials, subjects stepped off the foam pad, uncrossed their arms, and walked around for about 30 s.

2.3. Data collection, processing and analysis

The Opal recorded three-dimensional linear acceleration and angular velocity, sampled at 50 Hz and streamed via Bluetooth to a laptop. APDM software converted the signal to a true horizontal-vertical Cartesian coordinate system [16]; applied a 3.5-Hz cutoff, zero-phase, low-pass Butterworth filter; and computed previously validated outcome measures in the anteroposterior and mediolateral axes [14]. For analysis, we chose a subset of these measures that have been shown to be valid and reliable from a single sensor and are recommended for characterizing postural sway [14,17]: (1) amplitude (root-mean-square of the acceleration trajectory), (2) mean velocity (integrated from the acceleration signal); (3) path length (increases with both amplitude and velocity); (4) centroidal frequency (centroid of the signal's power spectrum); and (5) jerk (summed time derivative of acceleration trajectory). Each of these was separately reported for the anteroposterior (AP) and mediolateral (ML) axis. For each measure, the median value of the three trials was used for the across-subject averages in each condition. Repeated Measures Analyses of Variance (ANOVAs) were conducted in VassarStats. Significant ANOVA results were followed by Tukey tests, and significant post-hoc results were followed by assessments of effect size with Cohen's d.

Table 1
Postural Instructions.

Relaxed (baseline)	Effort-based	Light
Let your head feel heavy and sink forward and down a bit. Your neck muscles are relaxed, front and back. Your shoulders are relaxed, hanging heavy on each side of your body. Feel your breath in your belly.	Activate your core muscles to pull yourself up to your full height. Keep your head high and looking straight forward. Feel your neck and trunk muscles working strongly to pull you up. Lift your chest and pull your shoulders back.	Feel your body lengthening up without using any force from your muscles. Your bones send you up from the ground. Your head is easy and light at the top of your spine. The neck muscles and all other muscles are easy and don't tighten. Your shoulders and chest are open and wide.

3. Results

All subjects were able to perform the task and none reported any discomfort or difficulty. We excluded all data from two subjects whose results included values more than 3.5 standard deviations away from the group mean in any condition. (One of these subjects reported feeling sick, unrelated to our study.) Inferential statistics were run only after outlier removal. Results are shown in Table 2. Numerically, all values were highest in the effortful condition, indicating worst control of balance. Outcomes that were significantly higher in the Effort-based condition than in the Relax condition were amplitude and mean velocity (AP only), as well as path length and jerk (both AP and ML). Outcomes that were significantly higher in the Effort-based condition than in the Lighten-up condition were median frequency (AP only) as well as path length and jerk (both AP and ML). There were no significant differences between Relax and Lighten-up conditions.

4. Discussion

This study replicated in healthy young adults results seen previously in healthy older adults and in adults with Parkinson's disease [6,7]. Postural sway was larger and less smooth when participants followed the Effort-based instructions than when they stood in a Relaxed manner or followed our Light instructions, suggesting that postural instructions affected stability [14]. Previous work suggested that the Light instructions accomplish the beneficial goals of the Effort-based instructions, without the cost to balance and mobility [6,7].

Although young adults are known to have greater postural steadiness than older adults [8], relatively little is known about fall risk in young adults, who tend to be included in postural studies only as a control group. However, recent data suggest that falls – including injurious falls - are far more common in young adults than has been assumed [18,19]. It is likely that young adults are more willing to risk their postural stability (standing and walking on insecure surfaces, attending to distracting things in their environment, etc.) than older adults. Therefore, our results from stance on an unstable surface may have direct bearing on fall risk and public health.

The simplicity of the instructions used in this study and the reports from subjects that all conditions felt comfortable and easy support the external validity of the results. However, the short duration of practice did not allow us to assess whether longer practice with Effortful posture instructions would lead to adaptation such that balance would be less impaired. Future studies could investigate this question and could also look at the effects of postural instructions on dual-task gait, where fall risk for young adults may be highest [19].

In the initial test of these instructions in a sample with Parkinson's disease, the Light condition led to lower postural sway than either the Relaxed or Effort-based condition. In that study, postural tone was assessed and found to be lowest in the Light condition [7]. Perhaps the lack of a difference between the Light and Relaxed conditions in the healthy young adults studied here reflects differences in postural tone between healthy and Parkinsonian populations. Additionally, a static postural task may not be challenging enough to elicit differences between these conditions in healthy young adults. In healthy older adults, differences between Relaxed and Light conditions were revealed in a dynamic foot lifting task [6]. Future studies of these instructions with young adults should use a challenging, dynamic stability task.

Another limitation of this study is the absence of a fourth condition in which participants do not receive any postural instructions. Remedying this lack would help to clarify whether balance would be better served by replacing Effort-based instructions with Light instructions (which were objectively better than Relaxed instructions in the other two studies) or by eliminating instructions entirely.

Overall, these results support the growing scientific recognition that exhortations to "stand up straight" may do more harm than good [20].

Table 2
Effect of Relaxed, Effort-based, and Light instructions on attributes of postural sway. AP = anteroposterior. ML = mediolateral. RMS = root mean square. Vel = mean velocity. Path = path length. Freq= median frequency. d=Cohen's d.

	Mean (SD)			F (2,34), p	Tukey post-hoc: p-value, d		
	Relax	Effort	Light		R vs E	R vs L	E vs L
RMS - AP (m/s^2)	.070 (0.022)	0.088 (0.034)	0.078 (0.026)	4.7, 0.015	0.02, 0.6	0.09	0.08
RMS - ML (m/s^2)	.050 (0.012)	0.051 (0.016)	0.047 (0.011)	0.8, 0.461			
Vel - AP (m/s)	0.124 (0.064)	0.175 (0.084)	0.153 (0.057)	4.8, 0.015	0.02, 0.7	0.08	0.14
Vel - ML (m/s)	0.086 (0.031)	0.072 (0.027)	0.076 (0.024)	1.4, 0.25			
Path – AP (m/s^2)	5.47 (1.61)	6.34 (1.81)	5.23 (1.26)	11.2, 0.0002	0.01, 0.5	0.13	0.0003, 0.7
Path - ML (m/s^2)	4.51 (1.50)	5.15 (1.74)	4.48 (1.59)	13.2, < 0.0001	0.001, 0.4	0.79	0.002, 0.4
Freq - AP (Hz)	0.689 (0.161)	0.718 (0.153)	0.658 (0.139)	1.3, 0.283			
Freq - ML (Hz)	0.817 (0.189)	0.825 (0.202)	0.780 (0.218)	1.2, 0.308			
Jerk - AP (m^2/s^5)	.010 (0.006)	0.013 (0.007)	0.008 (0.004)	8.5, 0.001	0.04, 0.5	0.14	0.001, 0.7
Jerk - ML (m^2/s^5)	.007 (0.004)	0.009 (0.005)	0.006 (0.005)	12.5, < 0.0001	0.001, 0.4	0.51	0.002, 0.4

5. Conclusions

When participants stood quietly on springy foam, effort-based postural instructions increased the amplitude, path length, and jerk of their postural sway. These results are consistent with previous work in older adults indicating that thinking of upright posture as inherently effortful impairs balance. Therefore, the common practice of instructing people to use effortful posture may increase their risk of falls and unintentional injury. Postural instructions such as those used in Alexander technique, which encourages reduced effort combined with increased awareness of bony support, should be considered instead.

Conflict of interest statement

Neither author has any financial or personal relationships with other people or organizations that could inappropriately influence their work.

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