Gait & Posture 34 (2011) 496–501

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Prolonged weight-shift and altered spinal coordination during sit-to-stand in practitioners of the Alexander Technique

Timothy W. Cacciatore [a,b,*], Victor S. Gurfinkel [a], Fay B. Horak [a], Brian L. Day [b]

[a] Neurological Sciences Institute, Oregon Health & Science University, Beaverton, OR, USA
[b] UCL Institute of Neurology, Queen Square, London WC1N 3BG, UK

ARTICLE INFO

Article history:
Received 13 February 2011
Received in revised form 25 May 2011
Accepted 13 June 2011

Keywords:
Muscle tone
Posture
Sit-to-stand
Alexander Technique
Motor processes

ABSTRACT

The Alexander Technique (AT) is used to improve postural and movement coordination and has been reported to be clinically beneficial, however its effect on movement coordination is not well-characterized. In this study we examined the sit-to-stand (STS) movement by comparing coordination (phasing, weight-shift and spinal movement) between AT teachers ($n = 15$) and matched control subjects ($n = 14$). We found AT teachers had a longer weight-shift ($p < 0.001$) and shorter momentum transfer phase ($p = 0.01$), than control subjects. AT teachers also increased vertical foot force monotonically, rather than unweighting the feet prior to seat-off, suggesting they generate less forward momentum with hip flexors. The prolonged weight-shift of AT teachers occurred over a greater range of trunk inclination, such that their weight shifted continuously onto the feet while bringing the body mass forward. Finally, AT teachers had greatly reduced spinal bending during STS (cervical, $p < 0.001$; thoracic, $p < 0.001$; lumbar, $p < 0.05$). We hypothesize that the low hip joint stiffness and adaptive axial postural tone previously reported in AT teachers underlies this novel "continuous" STS strategy by facilitating eccentric contractions during weight-shift.

1. Introduction

The Alexander Technique (AT) is a method to improve habitual postural and movement coordination commonly used by performing artists [1]. It is offered in the music and theatre departments at major colleges for the purpose of improving performance and preventing injury. Recent reports indicate AT is clinically beneficial for back pain [2], Parkinson's disease [3] and balance in the elderly [4]. However, the mechanisms underlying its clinical and claimed performance improvements are poorly understood. A greater understanding of improved coordination could have broad implications for rehabilitation.

The emphasis of AT is on axial behavior, the positional and tensional relationships within the neck and trunk, during posture and movement [5]. In particular, AT aims to reduce unnecessary tension and maintain elongation along the spine, referred to as the head-neck-back relationship. Proponents consider this relationship fundamental to any clinical or performance benefit from AT [1,5].

Recently, AT has been found to alter postural tone. This was observed as a reduction of stiffness along the spine and hips in response to slowly applied torsion during unsupported stance [6]. Interestingly, this stiffness reduction resulted from an increase in the extent muscle tone dynamically adapted to yield to the applied movement. It is unclear, however, how such altered axial and proximal postural behavior may influence movement coordination. In general, the relationship between postural tone and movement coordination is not understood. In particular, the importance of regulating postural tone dynamically throughout movement has been hypothesized previously by Bernstein and others [7,8], but has not been studied to date. Populations with atypical axial postural tone, such as AT, might help elucidate how tone affects movement coordination.

AT is taught by bringing attention to one's head-neck-back relationship and specific features of movement, such as preparation and smoothness, in various postures and movements. A primary aim is to minimize abrupt shifts in tension and position along the body axis at movement onset [1,5,9]. AT instruction uses manual guidance to increase one's awareness of these features and facilitate the desired head-neck-back relationship. The resulting coordination is claimed to be more efficient [1,5,9]. Movements typically performed in AT include sit-to-stand (STS), stand-to-sit, knee bends, lunges and squats. Of these, only STS has been studied with AT. Jones et al. found that, for this movement, horizontal head velocity, vertical acceleration and cervical extension decreased

* Corresponding author at: Institute of Neurology, University College London, 33 Queen Square, Box 146, London WC1N 3BG, UK. Tel.: +44 0203 108 0087; fax: +44 0207 278 9836.
E-mail address: t.cacciatore@ucl.ac.uk (T.W. Cacciatore).

0966-6362/$ – see front matter.
doi:10.1016/j.gaitpost.2011.06.026

following AT training [10]. This group also found the movement was perceived as smoother and lower in effort [11]. Although AT may alter STS coordination, its effect is not well characterized and the significance of the resulting coordination differences is not clear.

In the present study, we aimed to better characterize STS coordination following AT training by examining (1) the overall phasing of the STS movement, (2) features of weight-shift, because it is perceived as smoother with AT, and (3) spinal coordination, because AT emphasizes axial behavior. A preliminary version of this work has appeared previously in abstract form [12].

2. Methods

2.1. Subjects

A total of 15 AT teachers (4 male, 11 female) participated in the study. AT teachers were selected as they are highly trained, spending 80% of their 1600-h training improving their own proficiency in AT. All teachers were certified by affiliates of the Society for Teachers of the Alexander Technique and had a mean age of 42.7 ± 9.1 years, height of 169.3 ± 8.5 cm, and weight of 74.5 ± 11.3 kg. The gender bias reflected that of US teachers. AT teachers had an average of 10.4 ± 9.3 years experience post-certification.

Fourteen control subjects (4 male, 10 female) were recruited to match the age, height, and weight of AT teachers: 38.1 ± 10.0 years ($F_{1,27} = 1.15$, $p = 0.29$), 164.7 ± 9.7 cm ($F_{1,27} = 2.29$, $p = 0.14$), and 70.8 ± 10.8 kg ($F_{1,27} = 0.56$, $p = 0.46$). All subjects were free of pain and orthopedic conditions and provided informed consent in accordance with the Oregon Health & Science University Institutional Review Board.

2.2. Experimental procedure

Subjects sat on an adjustable height backless chair with feet resting on a custom-built force plate. The chair height was adjusted to 105% of each subject's shank height (from floor to lateral knee epicondyle). Initial foot position was adjusted so the knee angle was 85° (Fig. 1). In pilot data, we observed AT teachers to have a prolonged, monotonic weight-shift when given no specific instruction regarding how to stand up. In the present study, we instructed participants to stand up "*as smoothly as possible, without using momentum*". This instruction aimed to encourage controls to mimic the gradual AT weight-shift, in order to understand whether it is simply a 'choice' of how to move or is difficult to perform, perhaps reflecting a more fundamental aspect of coordination. Subjects were told to start from sitting upright and to keep their arms crossed in front of their body. Subjects stood up at a self-selected speed 5 times.

2.3. Data collection

2.3.1. Kinematics

Kinematics were collected at 60 Hz using a 7-camera passive marker system (Falcon, Motion Analysis) and low-pass filtered at 6 Hz. Markers were placed bilaterally on the lateral orbital margin, tragus of the ear, posterior superior iliac spine, greater trochanter, lateral knee epicondyle, 3 cm proximal to the ankle joint along the fibula, lateral posterior calcaneus, and the head of the first metatarsal, as well as the spinal processes of C7, T4, T7, T10, L1, L4 and the midpoint of the sacral crest.

Trunk-tilt (θ_{trunk}) was defined as the sagittal plane segment angle from C7 to sacrum relative to vertical. Ankle angle (θ_{ankle}) was computed between ankle and knee markers relative to vertical averaged across both legs. Positive indicates dorsiflexion.

2.3.2. Forces

Forces were anti-alias filtered, sampled at 480 Hz and low-pass filtered at 15 Hz.

2.4. Data analysis

2.4.1. Movement phases

STS movement phases were calculated according to Schenkman [13] as follows. *Flexion-momentum phase* (Phase I) began when θ_{trunk} exceeded 5° of the seated value and ended when foot $F_z > 100\%$ bodyweight (t_{so}). The *momentum-transfer phase* (Phase II) occurred between t_{so} and the occurrence of max(θ_{ankle}). The *extension phase* (Phase III) occurred between max(θ_{ankle}) and when θ_{trunk} reached 5° of its value during stance. We did not examine the subsequent stabilization phase. To better quantify weight-transfer, we subdivided Phase I into *flexion-only* (Phase Ia) and *weight-transfer* (Phase Ib). Phase Ia ended and Phase Ib began when foot F_z exceeded 30% of bodyweight (BW). Phase durations were normalized by movement time (Phase I onset to Phase III cessation).

2.4.2. Monotonicity of weight-shift

Smoothness of weight transfer was examined by quantifying the monotoniticy of F_z before and after weight-shift as: undershoot = $100 \times (F_z(t_0) - \min F_z)/\text{BW}$; and overshoot = $100 \times (\max F_z - \text{BW})/\text{BW}$. This undershoot likely results from a hip flexor moment, which acts to accelerate the trunk forward and simultaneously lift the feet from the floor. Overshoot reflects the maximal leg extensor moments following seatoff.

2.4.3. Spinal angles

Spinal angles were computed between adjacent markers in the sagittal plane (e.g. θ_{T4} was computed between C7, T4 and T7) relative to the initial seated value. Positive indicates extension. Our pilot data revealed thoracic segments typically extended earlier than lumbar segments [14,15]. To decrease noise due to marker proximity, thoracic and lumbar angles were separately summed to obtain overall "joint" angles ($\theta_{thoracic} = \theta_{T4} + \theta_{T7} + \theta_{T10}$, $\theta_{lumbar} = \theta_{L1} + \theta_{L4}$). Neck angle was computed between C7, ear and orbit markers, averaged bilaterally to exclude head rotation.

2.4.4. Statistics

Measures were computed for each trial and averaged across repetitions. Significant differences between groups were determined using a one-way ANOVA with $\alpha = 0.05$.

3. Results

The mean duration to stand up was similar for control subjects (2.2 ± 0.9 s) and AT teachers (2.3 ± 0.5 s) ($F_{1,27} = 0.087$, $p = 0.77$).

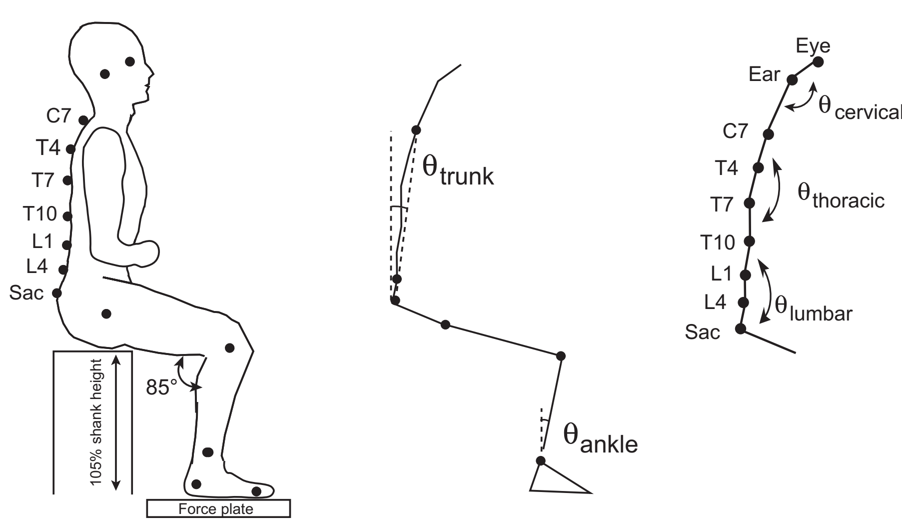

Fig. 1. Initial position and kinematic quantification. Left panel: Subjects began the movement from a standardized initial position with marker placements as shown. Middle panel: Trunk angle was calculated as the sagittal plane angle between C7 and the sacrum, relative to vertical. Right panel: The total sagittal thoracic angle ($\theta_{thoracic}$) was obtained by adding the individual joint angles at T4, T7 and T10 computed between adjacent markers. Similarly, θ_{lumbar} was obtained by summing L1 and L4 joint angles.