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Forward trunk lean with arm support affects the activity of accessory respiratory muscles and thoracoabdominal movement in healthy individuals

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ABSTRACT

Despite the reported benefits of postures involving leaning the trunk forward with arm support for relieving dyspnea, how those postures influence the mechanics of breathing remains unclear. In response, the aim of the study reported here was to evaluate how posture (i.e., standing and sitting) and leaning the trunk forward with arm support affect the activity of accessory respiratory muscles and thoracoabdominal movement in healthy individuals. Thirty-five volunteers (15 males and 20 females) aged 18–29 years breathed with the same rhythm in standing and sitting positions while upright and while leaning the trunk forward with arm support. Surface electromyography was performed to assess the activity of accessory inspiratory (i.e., during inspiration) and abdominal (i.e., during inspiration and expiration) muscles, and a motion capture system was used to assess thoracoabdominal movement. Results revealed that upper *trapezius* activity was significantly lower in forward-leaning postures than in upright ones ($P = 005$; $\eta_p^2 = 0.311$), although the activity of the *sternocleidomastoideus* and *scalenus* ($P < 0.001$; $\eta_p^2 = 0.427$–0.529), along with the anterior-to-posterior movement of the upper ribcage ($P < 0.001$; $\eta_p^2 = 0.546$), were significantly greater in forward-leaning postures than in upright ones. The activity of the external oblique and *transversus abdominis*/internal oblique was significantly lower in sitting than in standing postures ($P < 0.050$; $\eta_p^2 = 0.206$–0.641), and though the activity of the *transversus abdominis*/internal oblique was significantly lower in forward-leaning than in upright postures ($P \leq 0.001$; $\eta_p^2 = 0.330$–0.541), a significantly greater anterior-to-posterior movement of the abdomen was observed ($P < 0.001$; $\eta_p^2 = 0.662$). However, the magnitude of the lower ribcage's medial-to-lateral movement was significantly lower in forward-leaning than in upright postures ($P = 0.039$; $\eta_p^2 = 0.149$). Leaning the trunk forward with arm support not only increased the use of accessory inspiratory muscles but also decreased the use of the *transversus abdominis*/internal oblique, which improved thoracoabdominal movement.

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1. Introduction

Postures involving leaning the trunk forward with arm support – that is, the so-called "tripod position" – are often assumed to relieve dyspnea and improve pulmonary function (Bott et al., 2009; Gosselink, 2003; O'Neill & McCarthy, 1983). Research has shown that leaning forward improves the length-tension relationship and geometry of the diaphragm, which increases its output for breathing (Sharp, Drutz, Moisan, Foster, & Machnach, 1980). At the same time, in postures involving leaning the trunk forward, the efficacy of diaphragm contraction improves the motion of the chest wall, thereby enhancing changes in lung volume (Delgado, Braun, Skatrud, Reddan, & Pegelow, 1982). Although abdominal muscles may also assume an improved position for contraction with some degree of forward leaning (Dean, 1985), evidence regarding the recruitment of individual abdominal muscles in such postures and its impact on the thoracoabdominal movement remains scarce.

Postures involving leaning the trunk forward can also involve arm support (i.e., resting the forearms on the thighs or a surface) (Booth, Burkin, Moffat, & Spathis, 2014); however, the effect of that position on the activity of accessory inspiratory muscles and thoracoabdominal movement remains debatable. Sharp, et al. (1980) indicated the decreased contribution of the upper ribcage muscles (e.g., *sternocleidomastoideus*, SCM, and *scalenus*, Sc) in postures involving leaning the trunk forward with arm support, which consequently reduced energy expenditure. Conversely, other authors have shown that arm support increases the recruitment of those muscles and thus contributes significantly to ribcage elevation (Banzett, Topulos, Leith, & Nations, 1988; Kim et al., 2012).

Despite the reported benefits and physiological mechanisms of the tripod position, evidence to the contrary persists (Santos, Ruas, Sande de Souza, & Volpe, 2012). In response, we sought to elucidate the activity of inspiratory and abdominal muscles in postures involving leaning the trunk forward with arm support, as well as how the recruitment of accessory respiratory muscles in those postures affects thoracoabdominal movement. Thus, the aim of the study reported here was to evaluate how posture (i.e., standing and sitting) and leaning the trunk forward with arm support influence the activity of accessory respiratory muscles and thoracoabdominal movement in healthy individuals.

2. Methods

2.1. Sample

A study with a repeated measures design was conducted with a sample of 35 (15 males; 20 females) healthy higher education students (age: 21.43 ± 2.75 years; body mass: 61.95 ± 9.22 kg; height: 1.66 ± 0.08 m) volunteered to participate. Demographic and anthropometric data regarding the sample are described in Table 1. Participants had not participated in aerobic physical activities of moderate (i.e., at least 30 min on 5 days per week) or vigorous intensity (i.e., at least 20 min on 3 days per week) for more than 1 year. Aerobic training decreased the minute ventilation at a given absolute submaximal intensity, which appeared to relate closely to improved skeletal muscle oxidative capacity in peripheral and respiratory muscles (Thompson, 2014). Individuals with abdominal obesity (i.e., a waist-to-height ratio less than 0.5 and a waist-to-hip ratio less than 0.9 for men and 0.85 for women) (World Health Organization, 2011) were excluded from the sample, as were habitual smokers and individuals with chronic nonspecific lumbopelvic pain (i.e., recurrent episodes of lumbopelvic pain for a period exceeding 3 months), scoliosis, length discrepancy of the lower limbs or other postural asymmetries, neurological or inflammatory disorders, metabolic or cardiorespiratory diseases, pregnancy or delivery in the previous 6 months, long-term corticosteroid therapy, a history of spinal, gynecological, or abdominal surgery in the previous year, or any conditions that could have interfered with data collection. All participants provided their written informed consent in compliance with the Declaration of Helsinki, and their anonymity and the confidentiality of their data were guaranteed. The Institutional Research Ethics Committee also approved the study.

2.2. Instruments and procedures

2.2.1. Sample selection and characterization

An online questionnaire was sent to all participants to verify their fulfillment of inclusion criteria and to collect sociodemographic information. Anthropometric and body composition measures were assessed in all participants who met the criteria. Height (m) and body mass (kg) were measured respectively using a seca 222 stadiometer with a precision of 1.0 mm and a seca 760 scale with a precision of 1.0 kg (seca – Medical Scales and Measuring Systems, Hamburg, Germany). Waist circumference (cm) was measured

Table 1
Sample characterization: demographic, anthropometric and body composition data, with mean, standard deviation, minimum and maximum.

	Mean	Standard deviation	Minimum	Maximum
Demographic and anthropometric data				
Age (years)	21.43	2.75	18	29
Body mass (kg)	61.95	9.22	48.40	84.20
Height (m)	1.66	0.08	1.53	1.84
Body composition data				
Waist/height ratio	0.44	0.03	0.38	0.50
Waist/hip ratio	0.80	0.04	0.74	0.90