Human Movement Science 56 (2017) 20–28

Contents lists available at ScienceDirect

Human Movement Science

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

Full Length Article

Influence of anterior load carriage on lumbar muscle activation while walking in stable and unstable shoes

Frederik Petri Svenningsen[a], Emma Kaalund[a], Tine Åkær Christensen[a], Per Hedeager Helsinghoff[a], Nanett Yoo-Jin-Bruun Gregersen[a], Uwe Gustav Kersting[a], Anderson Souza Oliveira[b,*]

[a] Department of Health Science and Technology, Aalborg University, Aalborg, Denmark
[b] Department of Materials and Production, Aalborg University, Aalborg, Denmark

ARTICLE INFO

Keywords:
Low back
Ergonomics
Lumbar muscles
EMG
Walking
Stability
MBT shoes

ABSTRACT

Load carriage can be harmful for workers, and alternative interventions to reduce back pain while walking and carrying loads are necessary. Unstable shoes have been used to improve balance and reduce back pain, but it is unknown whether walking wearing unstable shoes while carrying loads anteriorly causes excessive trunk extensors muscle activation. The aim of this study was to investigate the effects of different shoe types and anterior load carriage on gait kinematics and lumbar electromyographic (EMG) activity. Fourteen adults that predominantly walk or stand during the work day were asked to walk with and without carrying 10% of body mass anteriorly while wearing regular walking shoes (REG) and unstable shoes (MBT). The effects of shoe type, load carriage, and shoe × load interactions on the longissimus thoracis (LT) and iliocostalis lumborum (IC) EMG, stride duration, and stride frequency were assessed. MBT shoes induced a significant increase in LT (44.4 ± 35%) and IC EMG (33.0 ± 32%, $p < .005$), while load carriage increased LT (58.5 ± 41%) and IC EMG (55.1 ± 32%, $p < .001$). No significant shoe × load interaction was found ($p > .05$). However, walking wearing MBT shoes while carrying loads induced a 46 ± 40% higher EMG activity compared to walking wearing MBT shoes without load carriage. No effects of shoes or load carriage were found on stride duration and stride frequency. It was concluded that walking wearing MBT shoes and carrying 10% of total body mass induced greater activation of trunk extensors muscle compared to these factors in isolation, such a combination may not influence gait patterns.

1. Introduction

There is an elevated number of low back injuries and recurrent pain in agricultural workers, health professionals, cleaners, and others required to walk while carrying loads in front of the body (van Vuuren, Becker, van Heerden, Zinzen, & Meeusen, 2005). Anterior load carriage during walking alters the body's center of mass position and the control of upright posture (Holbein & Redfern, 1994). Not surprisingly, anterior load carriage during walking demands greater trunk extensors muscle activation and overloading these muscles can lead to musculoskeletal disorders (Anderson et al., 2007). Despite all efforts to reduce musculoskeletal disorders in the workplace, a recent review (van Middelkoop et al., 2011) suggested only limited efficacy for physical and rehabilitation interventions to reduce low back pain when compared to no treatment. Therefore, alternative interventions to reduce the harmful effects

* Corresponding author.
E-mail address: oliveira@pm.aau.dk (A.S. Oliveira).

http://dx.doi.org/10.1016/j.humov.2017.10.010
Received 29 March 2017; Received in revised form 28 September 2017; Accepted 19 October 2017

of anterior load carriage on the low back are necessary.

Unstable shoes, such as Masai Barefoot Technology (MBT), consist of a rocker-sole designed to increase instability during standing or locomotion. These shoes were designed to improve postural control and reduce incidence of musculoskeletal injuries incidence (Papalia et al., 2015). Unstable shoes change the foot position and pressure distribution (Nigg, Hintzen, & Ferber, 2006; Romkes, Rudmann, & Brunner, 2006) and reduce stride duration during walking (Jandová, Volf, & Nagy, 2015). Moreover, unstable shoes reduce walking stability and consequently increase the activation of trunk extensors muscle activation (Buchecker, Stöggl, & Müller, 2013). This greater trunk extensors muscle activation has been interpreted as a beneficial stimulus (Behm, Drinkwater, Willardson, & Cowley, 2010; Buchecker et al., 2013), which in walking conditions can be considered sensorimotor training (Schiemann, Lohrer, & Nauck, 2015). Recent studies have shown that health professionals, whose working activities often involve standing and walking, reported lower pain scores after wearing unstable shoes for 6 weeks outside the work environment (Armand et al., 2014; Vieira & Brunt, 2016). Therefore, the use of unstable shoes has been considered an alternative intervention for adapting the musculoskeletal system to sustain loading.

Despite the growing interest in implementing unstable shoes as an intervention to improve trunk stability, there is a lack of research on the implications of using such shoes while manually handling loads. Anterior load carriage induces high demand for trunk extensors muscle activation (Anderson et al., 2007; Cook & Neumann, 1987; Motmans, Tomlow, & Vissers, 2006; Oliveira & Gonçalves, 2009), and anterior-posterior shear forces on the spine (Rose, Mendel, & Marras, 2013) of workers in their daily routines. As stated previously, the use of unstable shoes increases postural instability during standing or walking, consequently requiring greater trunk extensors muscle activation to maintain posture. Therefore, both unstable shoes *and* anterior load carriage can increase the demands for trunk extensors muscle activation, although for different reasons. It is possible to anticipate that walking wearing unstable shoes while carrying anterior loads may increase the activation of trunk extensors muscle for two reasons: 1) to counteract the instability caused by the shoes, which is considered a positive stimulus; and 2) to counterbalance the load being carried anteriorly to control the center of mass position. However, these combined effects of carrying loads while wearing unstable shoes on trunk extensors muscle activation is yet to be shown.

The aim of this study was to investigate the effects of different shoe types and anterior load carriage on gait kinematics and lumbar EMG activity. It was hypothesized that unstable shoes and anterior load carriage, as separate factors, would reduce stride duration, and increase trunk extensors EMG activity. Moreover, due to the different demands that unstable shoes and anterior load carriage can impose on trunk extensor muscles, it was hypothesized that walking wearing unstable shoes while carrying anterior loads would cause a cumulative increase in the lumbar muscle activation, when compared to the isolated use of unstable shoes or load carriage. This increase in trunk muscle activation might suggest that a combination of unstable shoes and load carriage may produce excessive loading on the trunk extensor muscles. Our results may provide insights into the positive and negative aspects of reducing walking stability, accompanying anterior load carriage, in the workplace when implementing the use of unstable shoes.

2. Methods

2.1. Participants

Fourteen adults (7 male, 7 female, 39.3 ± 6.8 years, height 175.7 ± 7.3 cm, mass 75.9 ± 12.6 kg) volunteered for the experiment. The main inclusion criterion was that their usual working activities involved primarily standing and walking while carrying some type of anterior load (nurses, car mechanics, janitors and cleaning assistants). Participants reported the amount of working time, and the total number of hours working while standing/walking during the recruitment process (Table 1). On average,

Table 1
Participant's profession, total working hours (Hours), minimum (S/W min) and maximum working hours standing or walking (S/W max) and load carried (10% body mass).

Participant	Profession	Hours	S/W min	S/W max	Load (kg)
1	Teacher	8	4	6	7.8
2	Chef	6	4	6	6.5
3	Hospital porter	8	7	8	8
4	Car mechanic	8	7	8	7.4
5	Nurse	8	4	6	6
6	Car mechanic	7.5	7	8	7.9
7	Car mechanic	7.5	4	6	10.1
8	Store manager	9	7	8	6.7
9	Team coordinator	9.5	4	6	9.1
10	Cleaning assistant	8	4	6	6.9
11	Janitor assistant	7.5	7	8	7.5
12	Hospital porter	8	7	8	7.9
13	Casino employee	7	4	6	8.7
14	Casino employee	7	4	6	5.3
	Average	7.70	5.29	6.86	7.56
	SD	0.78	1.48	0.99	1.21