Gait & Posture 41 (2015) 130–135

Contents lists available at ScienceDirect

Gait & Posture

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

Walking with wider steps increases stance phase gluteus medius activity

Samantha N. Kubinski [a], Christina A. McQueen [a], Keir A. Sittloh [a], Jesse C. Dean [a,b,*]

[a] Division of Physical Therapy, College of Health Professions, Medical University of South Carolina, Charleston, SC, United States
[b] Ralph H. Johnson Department of Veterans Affairs Medical Center, Charleston, SC, United States

ARTICLE INFO

Article history:
Received 17 August 2013
Received in revised form 12 June 2014
Accepted 17 September 2014

Keywords:
Biomechanics
Gluteus medius
Hip abduction
Locomotion
Step width

ABSTRACT

Increases in step width have been reported for several clinical populations, including older adults and stroke survivors. These populations often also exhibit decreased hip abductor strength, suggesting that walking with wider steps may be an adaptive response in order to reduce the mechanical demands on the hip abductors. The purpose of this study was to quantify the relationship between step width and gluteus medius (GM) activity during walking. Fourteen young, uninjured adults walked on a treadmill at 1.25 m/s for four step width conditions (*Normal*, *Narrow*, *Medium*, and *Wide*) while step width and stance phase GM electromyographic (EMG) activity were quantified. We also measured hip abduction torque and GM activity during maximum voluntary isometric contractions (MVICs) at three hip angles (neutral, abducted 10°, and abducted 20°). During walking trials, GM activity was significantly ($p < 0.0001$) influenced by step width; compared to *Normal* walking, GM activity was 47% higher with *Wide* steps and 24% lower with *Narrow* steps. We also observed a weak positive correlation ($r = 0.18 \pm 0.14$) between step width and GM activity during *Normal* walking, as GM activity was higher with wider steps. These results cannot be attributed to changes in GM conformation under the recording electrode, as GM activity was not influenced by hip angle during MVICs. The increased GM activity with wider steps does not support the proposal that increasing step width would be a beneficial adaptation to weakened hip abductors. A likely alternative explanation is that increased step width is a response to decreased gait balance.

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1. Introduction

Kinematic characteristics of human walking are commonly used to identify atypical gait patterns, and may provide insight into the underlying deficits. For example, an increased step width has been reported with increased age [1,2] and in patients post-stroke [3,4]. Walking with wide steps increases the metabolic rate [5,6], raising the question of why individuals would walk with this less economical gait pattern.

One possible explanation is that increases in step width are an adaptive response to reduced muscular strength. Specifically, decreases in hip abduction strength have been reported both with increased age [7] and following a stroke [8]. It is possible that walking with wider steps would reduce the mechanical demands on the hip abductors, allowing the task to be accomplished with less need for active force production by these weak muscles.

The purpose of this study was to determine whether step width influenced hip abductor activity among young, uninjured participants. We quantified step width and bilateral gluteus medius activity during trials in which step width was prescribed and trials in which participants walked with freely chosen step widths. In order to interpret changes in measured muscle activity, we accounted for possible effects of varying frontal plane hip angle on surface electromyographic (EMG) signals, which can potentially result from changing the conformation of the underlying muscle relative to the recording electrode [9]. Based on the potential link between hip abductor strength and step width among clinical populations, we hypothesized that walking with wider steps would decrease the required stance phase gluteus medius activity.

2. Methods

2.1. Participants

Fourteen adults (10 female, 4 male; age = 24 ± 2 years; mass = 64.8 ± 11.2 kg; leg length = 0.88 ± 0.06 m) participated in this study. Potential participants with self-reported current lower

* Corresponding author at: 77 President Street, MSC700, Charleston, SC 29425, United States. Tel.: +1 843 792 9566; fax: +1 843 792 1358.
E-mail addresses: deaje@musc.edu, jesse.c.dean@gmail.com (J.C. Dean).

http://dx.doi.org/10.1016/j.gaitpost.2014.09.013
0966-6362/Published by Elsevier B.V.

extremity injuries, or a history of cardiac, respiratory, or neurological disease were excluded. Written informed consent was obtained from each participant using a form approved by the Medical University of South Carolina Institutional Review Board and consistent with the Declaration of Helsinki.

2.2. Equipment

All walking trials were performed on a treadmill (Bertec; Columbus, Ohio), while participants wore a harness attached to an overhead rail which did not support body weight, but would have prevented a fall in case of a loss of balance. Spatiotemporal walking data were collected at 120 Hz using active LED markers placed on the left and right heels (PhaseSpace; San Leandro, California). In separate trials, a dynamometer (Biodex Medical Systems; Shirley, New York) was used to quantify isometric hip abduction strength (sampled at 1000 Hz) in a standing posture.

During both walking and strength testing trials, electromyographic (EMG) activity of the gluteus medius (GM) muscles was sampled at 1000 Hz using bipolar surface electrodes with two 12 mm sensor disks separated by 17 mm (Motion Lab Systems; Baton Rouge, Louisiana). Electrodes were placed based on previously published SENIAM guidelines [10], after cleaning the skin over the GM with alcohol. Prior to testing, we ensured that the electrode placement allowed clear detection of GM activity with a minimal risk of cross-talk from other hip muscles. Participants performed isolated hip contractions (abduction, adduction, extension, and flexion) against manual resistance while we ensured that activity was clearly present during abduction contractions and minimal during contractions in other directions, a typical method of testing for cross-talk [11,12]. In the case of visually detectable activity during a contraction in one of these other directions, the electrodes were moved and retested.

2.3. Experimental protocol

Participants walked at 1.25 m/s, a typical walking speed for young adults previously used to investigate the relationship between step width and metabolic rate [5]. Walking speed was constant across trials and individuals to avoid any complicating effects of walking speed on preferred step width [13]. To become comfortable with walking while looking straight ahead, participants first performed a 5-min warm-up trial. Each participant's preferred step frequency was measured during the final minute of this trial, and used to prescribe step frequency during the remaining trials.

Participants performed a series of four 3-min walking trials in randomized order: *Normal*, *Narrow*, *Medium*, and *Wide*. For the *Normal* trial, participants were simply instructed to walk normally. In the remaining trials, step width was prescribed through verbal instructions. For the *Narrow* trial, participants were instructed to walk with narrow steps, such as by placing their feet directly in front of each other. For the *Medium* trial, participants were instructed to walk with a typical step width (i.e. not narrow or wide), but to keep this step width constant from step to step. For the *Wide* trial, participants were instructed to walk with the widest steps they could comfortably maintain throughout the walking period. Visual targets of the prescribed step width were intentionally not provided in order to prevent participants from "aiming" their steps. Instead, participants were instructed to look straight ahead while walking. The purpose of performing the *Medium* trial was to determine whether simply asking participants to pay attention to their step width had an influence on muscle activity (a psychological effect), beyond any potential effects of step width itself. To prevent participants from stepping off the treadmill belt, an experimenter provided verbal feedback if participants moved substantially away from the middle of the treadmill. For each trial, participants were instructed to match their step frequency to a metronome, which was set to the individual's previously measured preferred step frequency. A 3 min rest period separated walking trials.

Following the walking trials, participants performed a series of hip abduction maximum voluntary isometric contractions (MVICs) with their right leg. All trials were performed while standing on the left leg, following previously described methods [14]. The mediolateral location of the right hip joint center [15] was aligned with the axis of a dynamometer (Fig. 1A). Participants were permitted to stabilize their posture by holding onto the frame of the dynamometer, and an experimenter provided verbal and tactile feedback (i.e. lightly touching the participant's trunk) to prevent participants from leaning laterally.

Participants performed hip abduction contractions at three hip angles in randomized order: neutral position, 10° abduction, and 20° abduction. The purpose of these trials was to determine whether the measured GM activity was influenced by hip angle, as could be caused by changes in muscle conformation under the recording electrodes. The chosen 20° range exceeded published values of hip abduction displacement during walking [16],

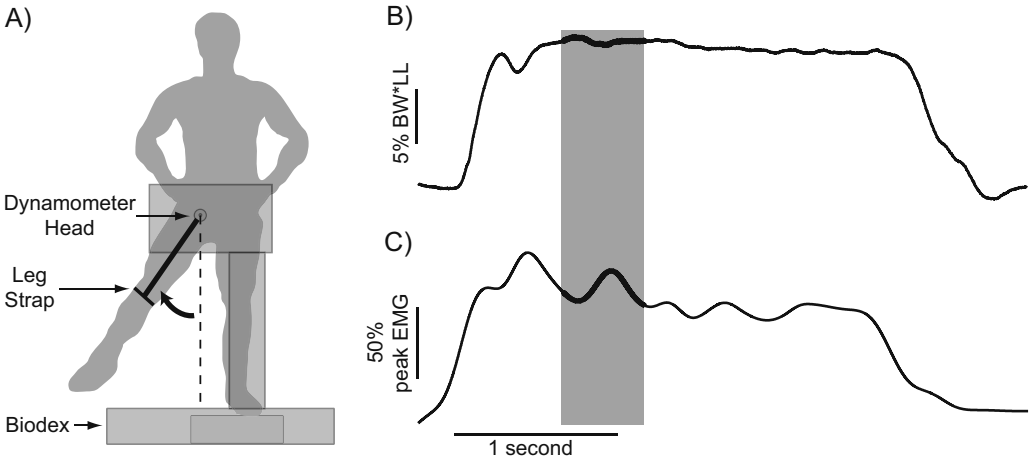

Fig. 1. Participants performed MVIC hip abduction contractions while torque and gluteus medius activity were recorded. (A) Contractions were performed from a standing posture. (B) Abduction torque was quantified during the 0.5 s period in which the average torque was highest (shaded box). (C) Processed gluteus medius activity was quantified during the same time period.