Gait & Posture 38 (2013) 1005–1009

Contents lists available at SciVerse ScienceDirect

Gait & Posture

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

No evidence hip joint angle modulates intrinsically produced stretch reflex in human hopping

W. Gibson [a,b,*], A. Campbell [b], G. Allison [b]

[a] School of Physiotherapy, The University of Notre Dame Australia, Fremantle, WA, Australia
[b] School of Physiotherapy, Curtin University, Perth, WA, Australia

ARTICLE INFO

Article history:
Received 14 May 2012
Received in revised form 6 May 2013
Accepted 19 May 2013

Keywords:
Stretch reflex
EMG
Hopping
Gait

ABSTRACT

Motor output in activities such as walking and hopping is suggested to be mediated neurally by purported stretch reflex augmentation of muscle output. Reflex EMG activity during these tasks has been frequently investigated in the soleus muscle; with alterations in reflex amplitude being associated with changes in hip joint angle/phase of the gait cycle. Previous work has focussed on reflex activity induced by an artificial perturbation or by induction of H-reflexes. As such, it is currently unknown if stretch reflex activity induced *intrinsically* (as part of the task) is modulated by changes in hip joint angle. This study investigated whether hip joint angle modulated reflex EMG 'burst' activity during a hopping task performed on a custom-built partially reclined sleigh. Ten subjects participated; EMG and kinematic data (VICON motor capture system) was collected for each hop cycle. Participants completed 5 sets of 30 s of self-paced hopping in (1) hip neutral and (2) hip 60° flexion conditions. There was no difference in EMG 'burst' activity or in sagittal plane kinematics (knee/ankle) in the hopping task between the two conditions. The results indicate that during a functional task such as hopping, changes in hip angle do not alter the stretch reflex-like activity associated with landing.

1. Introduction

The monosynaptic short latency stretch reflex (SR) is a spinal reflex arc that can be defined as the sudden peak in motor output that occurs after a stretch stimulus is applied to a muscle [1]. This therefore implies the reflex is mediated via peripheral afferent feedback. Substantial attention has been given to the contribution of peripheral afferent input and by association the SR mechanism in modulating/augmenting human [2,3] and animal gait [4].

The peripheral afferent mediated SR response of the triceps surae muscle group (focussing on the soleus muscle) is considered to be particularly important in modulating stiffness and motor control around the ankle joint in activities ranging from walking [2,5] and landing [6,7] to hopping [8]. Triceps surae SR responses elicited by rapid perturbations applied to the ankle joint during treadmill walking led Yang et al. [9] to suggest that 30–60% of soleus activation during stance phase is attributable to neurally mediated SR activation. This purported SR contribution to soleus activation during gait has been demonstrated to be phase dependant such that early and mid-stance phases show greater SR responses as compared to late stance/early swing phases [2,3,5].

This observed phase dependency on elicited SR amplitude has been strongly linked to hip position. In an elegant study, Kawashima et al. [10] demonstrated modulation of elicited triceps surae SR amplitudes by alterations in hip positions. Importantly, this study included subjects with a complete spinal cord injury, thus alterations in SR amplitude caused by changes in hip position can be more strongly attributed to purely peripheral afferent input as opposed to supraspinal influences [10]. Additional support for the modulation of SR by hip position is provided by a number of studies in which similar alterations in H-reflex amplitude were observed across differing ipsilateral/contralateral hip joint angles [11–14] although it is recognised that H-reflex responses and stretch reflexes are not directly comparable, despite utilising similar reflex pathways.

It is important to note that studies examining reflex activity during gait do so by utilising artificially induced reflex responses. This is most commonly done via H-reflex induction (a highly synchronised, monosynaptic 'reflex' activation of a muscle following external electrical stimulation) [11,13,14] or by employing an externally applied device to provide artificial perturbations eliciting triceps surae SR type activity [2,3,10]. These constructs are subtly different from a stretch reflex produced intrinsically as part of movement, particularly in light of recent findings demonstrating

* Corresponding author at: School of Physiotherapy, The University of Notre Dame Australia, Fremantle, WA, Australia. Tel.: +61 894330589.
E-mail address: william.gibson@nd.edu.au (W. Gibson).

0966-6362/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.gaitpost.2013.05.007

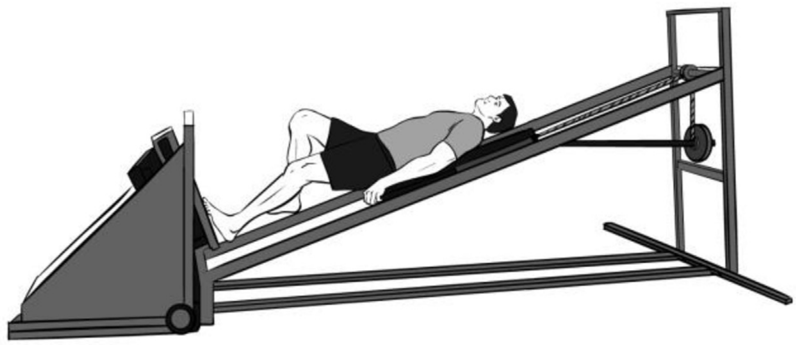

Fig. 1. The custom made inclined partial weight bearing sleigh used to perform the hopping task. Note the design whereby free weights are used to offset the weight of the sled seat.

intrinsic SR activity may well involve supraspinal modulation [15]. Therefore at present it is unknown whether triceps surae SR modulation with hip joint angle changes occurs when the SR is intrinsic to the movement; not artificially applied.

Rhythmic activity such as hopping is thought to elicit intrinsic SR activity [8] and it is postulated this activity may aid in optimising efficiency of the movement [6,8]. It is assumed the SR response is elicited via the rapid dorsiflexion of the ankle when landing during hopping and this is evidenced by a consistent 'burst' of soleus electromyographic (EMG) activity occurring with a latency of around 45 ms following foot contact [6,8,15].

This study therefore aimed to determine how a change in hip angle modulated the representative EMG 'burst' of the *intrinsically* produced short-latency SR response during a supported hopping task. The supported hopping task was performed under partial weight bearing conditions on a custom built inclined sleigh in order to minimise external factors such as fatigue during the task (see Fig. 1).

2. Methods

2.1. Participants

The experiment was performed on ten healthy adults (eight males and two females; age range 22–41 years). All participants were in good health with no ongoing or current lower limb or spine pain. All participants provided informed written consent, and ethics approval was obtained from the Curtin University Human Research Ethics Committee (PT0137).

2.2. Instrumentation

Data was collected at the Curtin University motion analysis laboratory. An incline (30° to horizontal) sleigh apparatus designed similar to previous work [16] with a low friction sliding mechanism enabled participants to perform a continuous supported hopping task. This task was used in preference to upright hopping in order to minimise fatigue, a potential confounding variable. An AMTI force plate sampled at 4000 Hz and affixed at 90° to the base of the sleigh, was used as an event marker, recording the landing point of each hop. A Noraxon EMG system sampled at a frequency of 4000 Hz was used to measure the amplitude of soleus muscle activity during the hopping task. Kinematic variables were measured with a 14 camera Vicon motion capture system from Oxford Metrics Group, run at a speed of 250 Hz.

2.3. Procedures

Following arrival to the Motion analysis laboratory, the Vicon motion analysis marker set was affixed to each participants pelvis and dominant side lower limb, on the anatomical landmarks as described in previous protocols [17]. In preparation for the placement of surface electrodes, the skin on the anterior and posterior lower leg was rubbed with fine sandpaper and alcohol swabs to reduce skin impedance. Red Dot 3M surface electrodes were placed over the muscle belly of the soleus muscle in line with SENIAM recommendations [18], with a reference electrode over the lateral malleolus. Participants were then set up on the inclined sleigh apparatus with the knee of the dominant lower limb secured with two straps (one above and one below the knee joint) in an attempt to limit knee joint flexion and maintain consistency across trials. Participants were set up in two different positions for testing. Firstly they were required to lie supine on the sleigh so that the hip joint was in neutral, and secondly their trunk was elevated by a backrest that allowed them to perform the task with the hips in 60° flexion.

One static trial was performed to record the location of the anatomical landmarks on the Vicon motion analysis system. Participants were then read a standardised set of instructions and were allowed a short warm up and familiarisation to the sleigh system. For the testing, participants were required to perform 5 sets of 30 s of continuous self-paced hopping on the force plate at the base of the sleigh. This was performed both in the hip neutral position as well as the hip flexed position. Subjects had at least two minutes rest between hopping trials. This protocol was used in preference to a single repeated drop jump protocol due to its high level of trial to trial reliability and consistency in technique between subjects [19].

2.4. Data reduction

The Vicon trajectories were inspected using Vicon nexus software (Oxford Metrics Inc.) for breaks that can occur when markers are occluded. Breaks of less than 20 frames were filled using cubic spline interpolation. Any trial that contained breaks larger than this were to be discarded, however this did not occur. A residual analysis was then used to determine the optical filter frequency for the Vicon trajectories and force plate data, and a low pass Butterworth filter was used to filter the data using a cut off frequency of 18 Hz.

EMG and kinematic data for each hop was collected for all trials and averages of these values were used for further analysis. A custom LabVIEW program (National Instruments Inc.) was developed to output the kinematics and EMG data for each hop cycle from 128 ms prior to foot contact to 128 ms post foot contact.

The EMG trials were synchronised and the absolute values averaged to form an ensemble for each individual condition from which the derived variables were determined. These averaged EMG traces of the hopping trials were then visually inspected for the characteristic 'burst' of activity as evidence of the stretch reflex