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Moderate alterations in lower limbs muscle temperature do not affect postural stability during quiet standing in both young and older women

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Abstract

Older adults demonstrate increased amounts of postural sway, which may ultimately lead to falls. Temperature is known to have a profound effect on the performance of the neuromuscular system which could have important implications on motor control. It is, therefore, of interest to investigate if the age-related decline in postural stability could be affected by changes in local limbs temperature.

The present study investigated the effects of localized warming and cooling on postural sway in nine young (22 ± 3 years) and nine older (73 ± 3 years) women. Postural sway was assessed, using a single force platform, during quiet standing at three muscle temperature conditions: control (34.2 ± 0.2 °C), cold (31.3 ± 0.3 °C) and warm (37.0 ± 0.1 °C). Two stances were evaluated, the Romberg (large support base) and modified Tandem (narrow support base), under both eyes-open and eyes-closed conditions. Root mean square (RMS), mean velocity (MV), sway area (SA) and mean power frequency (MPF) were calculated from the centre of pressure (COP) displacement.

Neither warming nor cooling significantly affected any of the postural parameters which were, however, all higher ($P < 0.05$) in the older group than the young group in all conditions. This study demonstrated that, in quiet standing conditions, a moderate variation (±3 °C) in lower limbs temperature does not affect postural steadiness in either young or older women.

Keywords: Older individuals; Force platform; Postural sway; Romberg; Tandem

1. Introduction

Detection and response to sway during standing is vital to the maintenance of successful postural control. Signals from the vestibular, visual and proprioceptive sensory systems are integrated to provide the nervous system with the information necessary in achieving this task (Horak and Macpherson, 1996). A known consequence of aging is represented by deleterious changes to the structure and function of the proprioceptive system, which contribute to the increased postural instability and consequently an increased risk of falls in the older population (Stelmach and Worringham, 1985; Maki and McIlroy, 1996). Indeed, correlations have been reported between the stretch reflex onset latency and postural sway in adults of increasing age, with a slower onset latency resulting in a greater postural sway (Nardone et al., 1995).

In light of these age-related alterations in the mechanisms which maintain postural control it is also of interest to consider external factors which could potentially contribute to alter postural stability (Maki and McIlroy, 1996). Temperature is known to have a profound effect on the neuromuscular system (Rome, 1990; Hodgkin and Katz, 1949); a linear relationship is known to exist between the conduction velocity of a nerve and its local temperature

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[for review see (Rutkove, 2001)]. Further, a recent investigation has demonstrated a lengthening of the reflex onset latency with cooling and a shortening of the onset latency with warming in both older and young individuals (Dewhurst et al., 2005). Older subjects, however, exhibit slower onset latency than young even in normal temperature conditions. Therefore, a further delay induced by cooling could have critical effect on the ability to successfully maintain postural steadiness in an older population.

The aim of the present study was, therefore, to investigate the effects of decreased and increased local temperature on the postural stability in young and older women. The study was conducted on women since, with advanced age, they exhibit higher rate of falls and related injuries than men (Schultz et al., 1997). It has been also shown in a prospective study that in the winter period the observed increase in the rate of falls in the older population was observed in women but not in men (Campbell et al., 1988).

2. Methods

2.1. Participants

Nine young (aged 22 ± 3 years; body mass 59 ± 3 kg; stature 1.64 ± 0.08 m) and nine older (73 ± 3 years; body mass 68 ± 11 kg; stature 1.61 ± 0.07 m) females gave written consent to participate in the study after being fully informed about the investigation and the possible related risks and discomforts. Young subjects were healthy with no known neuromuscular disorders. Older subjects were considered medically stable as proposed by Greig et al. (1994). All subjects were moderately active participating in non-competitive, physical activities no more than twice a week. Ethical approval for the experimental procedures was obtained from the local University Ethics Committee.

2.2. Experimental design

After an initial familiarization session, subjects attended the laboratory on a single occasion during which all tests were performed. Minimal physical activity was performed and no caffeine or alcohol was permitted 24 h prior to the testing session. Following subject preparation subjects performed the control trial first, which was followed by both a warming and cooling trial administered in a counterbalanced fashion.

2.3. Temperature measurements

Muscle and the skin temperatures were measured from the dominant leg, muscle temperature was continually measured from the vastus lateralis muscle using a flexible temperature probe (Ellab Ltd., Copenhagen, Denmark) inserted 1 cm below the subcutaneous fat layer at an angle of 45° in the direction of the muscle fibres. The thermistor was inserted through a flexible cannula (Venflon 18 GA, Becton Dickinson, Sweden) and advanced ~0.5 cm beyond the end of the cannula into the muscle. Skin temperature was measured using skin thermistors (Grants Instruments Ltd., Cambridge, UK) from two sites, the vastus lateralis (close to the muscle probe) and the soleus (muscle belly). Muscle and skin temperatures were recorded from Medical Precision Thermometer (DM 852, Ellab Ltd., Copenhagen, Denmark) and 1000 series 8-bit squirrel data logger (Type 1002, Grants Instruments Ltd., Cambridge, UK), respectively. Core temperature was estimated using an infrared tympanic thermistor (Braun, type 6013, Germany).

The subjects rested in the supine position for 30 min at room temperature (≅26 °C) to achieve steady state temperatures. Temperatures recorded immediately after the 30 min rest were considered the control temperatures. Following the balance performance assessment under the control temperature condition, temperature of the legs was increased using electrically heated blankets or decreased using a specifically made ice blanket consisting of large thick plastic sacks filled with crushed ice. In both temperature conditions blankets covered the whole of both legs from the gluteal furrow to the foot. Warming and cooling proceeded until muscle temperature was increased or decreased by approximately 3 °C with respect to the control muscle temperature. Muscle temperature was monitored throughout the trial to ensure the desired value was maintained. Blankets were removed during each trial but were applied again during the rest period between trials.

2.4. Data acquisition and analysis

Balance performance was assessed during quiet standing in two positions, one with a large support base (the Romberg position) and the other with a narrow support base (modified Tandem position). For each trial subjects stood barefoot, centrally aligned on the force plate. The Romberg position involved the subject standing feet together with their arms lying along legs, whilst in the modified Tandem position the subjects took a small step back with their dominant foot so the feet were aligned heel to toes but not directly behind one another, again with the arms lying along legs. Subjects kept the position for 35 s, although the initial 5 s were not included in the subsequent analysis. Trials for both stance positions were performed under two visual conditions, eyes open and eyes closed administered in a randomized order. Each trial was repeated three times, with 2 min rest between trials. During the open-eyes trials subjects had to focus on a visual target placed two meters in front of the subjects at eye level, spectacles were worn if required. Data were obtained using a piezo-electric force platform (Kistler 9261A, Winterhur, Switzerland) adopting a sampling frequency of 100 Hz. Data from the force platform were amplified (Kistler, charge amplifier, 9865B), A/D converted before being transferred to a PC. Data were low-pass filtered using a 4th order Butterworth filter with a 5 Hz cutoff frequency. Subsequently, the following centre of pressure (COP) based parameters were calculated: root mean square (RMS) and mean velocity (MV), as represen-