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ORIGINAL RESEARCH

Walking with a four wheeled walker (rollator) significantly reduces EMG lower-limb muscle activity in healthy subjects

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summary *Objective:* To investigate the immediate effect of four-wheeled- walker(rollator) walking on lower-limb muscle activity and trunk-sway in healthy subjects.
Methods: In this cross-sectional design electromyographic (EMG) data was collected in six lower-limb muscle groups and trunk-sway was measured as peak-to-peak angular displacement of the centre-of-mass (level L2/3) in the sagittal and frontal-planes using the SwayStar balance system. 19 subjects walked at self-selected speed firstly without a rollator then in randomised order 1. with rollator 2. with rollator with increased weight-bearing.
Results: Rollator-walking caused statistically significant reductions in EMG activity in lower-limb muscle groups and effect-sizes were medium to large. Increased weight-bearing increased the effect. Trunk-sway in the sagittal and frontal-planes showed no statistically significant difference between conditions.
Conclusion: Rollator-walking reduces lower-limb muscle activity but trunk-sway remains unchanged as stability is likely gained through forces generated by the upper-limbs. Short-term stability is gained but the long-term effect is unclear and requires investigation.

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Introduction

Rollators are four-wheeled walkers commonly used in clinical practice in many patient groups (Gupta et al., 2006; Chee et al., 2013; Eggermont et al., 2006; Smith et al., 2012). The specific aims of rollator use vary depending on the patient diagnosis. For example, in the elderly or patients with neurological disease such as multiple sclerosis, rollators are used to increase walking endurance and muscle strength or to improve balance (Chee et al., 2013; Vogt et al., 2010; Braun et al., 2014). Following surgery, reduced weight bearing or pain may be treatment goals (Smith et al., 2012), whereas in patients with chronic obstructive pulmonary disease improvement of functional exercise capacity and reduction of dyspnoea can be the objectives (Gupta et al., 2006).

To optimally prescribe rollators therefore, clear treatment goals for each patient are necessary as well as a thorough understanding of the biomechanical and physiological effects of rollator walking.

Despite this, the biomechanical effects have only been sparsely investigated. Alkjaer et al. (2006) assessed sagittal and frontal plane kinematics and joint dynamics in the lower limbs of seven healthy women walking with and without rollators. They concluded that walking with a rollator unloaded the knee and ankle extensors (which would reduce extensor muscle activity at these joints although this was not directly measured), whilst increasing hip extensor load (which would suggest increased hip extensor muscle activity).

Ishikura (2001) did investigate muscle activity with surface electromyography (EMG) when walking with walker at varying degrees of hip flexion. This study concluded that muscle activity in both the rectus femoris and biceps femoris was reduced during walker gait and that reduction in activity increased with increasing hip flexion.

To our knowledge no further studies have investigated the effect of rollator walking on muscle activation. The shortage of such studies as well as the partially contradictory conclusions of those mentioned above (Ishikura (2001) stating that muscle activity is reduced, Alkjaer et al. (2006) suggesting that it would be increased in hip extensors) mean that the influence of rollator walking on muscle activity remains unclear although this is an important consideration during clinical prescription. If muscle activity is reduced during rollator walking, long term use may reduce muscle strength. This could be relevant for patients groups in which rehabilitation aims to maintain or increase muscle strength e.g. geriatric or neurologically impaired patients. On the other hand, reduction in muscle activity may be important for some patients e.g. to unload joints following surgery. A clearer understanding of the effect of rollator walking on muscle activity would improve the appropriate and evidence based prescription of these devices.

The influence of rollators on the control of balance also remains unclear. Alkjaer et al. (2006) stated that "hip range of movement in the frontal plane was significantly less walking with a rollator than without". At the same time, the internal hip abductor moment was reduced.

In this situation reduced abductor moment would likely be due to reduced hip abductor muscle activity (although this was not directly measured) which would cause contralateral pelvic drop during single leg stance and therefore increased movement in the frontal plane. This in turn would increase trunk sway peak to peak angular displacement of the Centre of Mass (CoM) (Allum et al., 2001) indicating balance instability (Corporaal et al., 2013; Gill et al., 2001; Goutier et al., 2010). The importance of hip abductor control in balance stability has long been established (Runge et al., 1999; Winter et al., 1996) and more recently confirmed (Gribble and Hertel, 2004; Negahban et al., 2013).

Additionally lateral spontaneous sway amplitude was found to be the single best predictor of future risk of falling in an elderly population (Maki et al., 1994).

The fact that hip range of motion in the frontal plane did not increase despite reduced hip abductor activity, suggests that other mechanisms than hip abductor muscle activity were responsible for maintaining frontal plane pelvic stability. Pardo et al. (1993) investigating rollator use in patients with lower limb amputations suggested that these stabilizing mechanisms are generated by the upper limb reaction forces and moments at the walker. This could mean that rollator use facilitates use of the arms and reduces typical patterns of muscle activation in the lower limbs to maintain stability. Compensatory, abnormal balance reactions to maintain stability may therefore be encouraged during rollator walking.

Rollators also increase the base of support (BoS) during standing and walking (Bateni and Maki, 2005). As balance comprises maintaining the CoM within the limits of the BoS, (Bateni and Maki, 2005; Pai and Patton, 1997) rollator use, through increasing the BoS, makes it easier to balance.

These points would be important considerations in the prescription of rollators. When rehabilitation aims to improve balance reactions, a walking aid which does not facilitate normal reactions is possibly not optimal e.g. in fall prevention programs or in early post-stroke recovery. Alternatively, when improvement of balance control is not the priority of treatment, rather the provision of stability to enable independent mobility e.g. in some eldery patient groups, a rollator may be the appropriate device.

This study aims to investigate the effect of rollator walking with normal and increased weight bearing on muscle activity in the lower extremities and concurrently on trunk sway in comparison to walking without a rollator in healthy subjects.

We suggest that if the person pushes on the rollator toward the ground, a rollator force in the opposite rotary direction to the body weight force will be generated (see Fig. 1).

The reactive rollator force will form force couples with the hip extensor, abductor and ankle plantar flexor muscle groups, the force couples being equal and opposite to the bodyweight. The contribution of muscle activity necessary to oppose the effects of body weight will therefore be reduced. Increasing push on the rollator will increase the reactive rollator force thus further reducing muscle activity.

Our first hypothesis is therefore that rollator walking will reduce hip extensor, abductor and plantar flexion muscle