1-1-2013

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Abstract

Abstract of paper that presented at the Eleventh Footwear Biomechanics Symposium, Natal, Brazil, 2013.

Keywords

effects, flexor, age, muscles, strength, toe

Publication Details

Mickle, K. Julie., Angin, S., Crofts, G., Steele, J. R. & Nester, C. 2013, 'Effects of age on strength of the toe flexor muscles', Footwear Science, vol. 5, no. Suppl. 1, pp. S57-S58.

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Mickle, K J & Angin, S & Crofts, G & Steele, J R & Nester, C 2013, 'Effects of age on strength of the toe flexor muscles', #Proceedings of the Eleventh Footwear Biomechanics Symposium#Vol 5, Supplement 1 edition#Taylor & Francis#Natal#Brazil.

Abstract

Effects of age on strength of the toe flexor muscles

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Introduction
Correct toe function is imperative for performing many important activities of daily living. Mechanically, the toes are critical because they have the longest lever arm relative to the ankle of any part of the foot. Thus, by applying pressure to the ground toes are able to correct for unexpected postural disturbances, help maintain balance and ensure we can walk safely.

A decline in muscle strength is typically regarded as an inevitable consequence of ageing, and age-related loss of muscle mass is one the main determinants of frailty. The decline in muscle strength tends to appear around the sixth decade (Vandervoort and McComas 1986; Narici et al. 1991), and is associated with reduced walking speed and increased risk of disability and falls (Latham et al. 2004). For example, older adults have been found to have a two- to threefold increase in intramuscular non-contractile (e.g. fat) tissue within the tibialis anterior (shank) muscle compared to younger adults (Kent-Braun et al. 2000). These changes can arise from muscle disuse and are inversely associated with changes in physical activity (Kent-Braun et al. 2000).

It is speculated that muscles within the feet, including those that control the toes, also suffer from atrophy with ageing. It is thought that this span style="color: windowtext; font-size: 12pt">leads to an imbalance between toe flexor and extensor muscles, and is perhaps the primary cause of claw and hammer toe deformities (Myerson and Shereff 1989; van Schie et al. 2004). However, there is a paucity of literature characterizing foot muscle strength in older people. This deficit in knowledge should be addressed in order to determine the effects of ageing on the foot as a basis for developing intervention strategies to preserve efficient foot and toe function.

Purpose of the study
Thepurposeofthis study was to compare toe flexor strength of older adults relative to their younger counterparts.

Methods
Fourty-one young adults (18-50 years) and 44 older adults (60+ years) were recruited to participate in the study. Each

particiant had their feet assessed using the Foot Posture Index (Redmond et al. 2006) and the presence of any toe deformities (e.g. hallux valgus, claw/hammer toes) were recorded.

Toe flexor strength was then assessed while each subject stood on an emed X pressure platform (Novel$_{gmbh}$). During each trial participants were instructed to push down as hard as possible onto the platform under two conditions: i) using their lesser toes, or ii) using only their hallux. Maximum force (N) under the hallux and lesser toes were calculated and then normalised to body mass (% BW).

Individuals from the younger cohort who had a normal foot type (FPI 0-5), were matched by gender (18 males, 16 females) and BMI to adults from the older group with a normal foot type and without any toe deformities to form the Young and Old comparison groups. Independant *t*-tests were then used to determine whether toe flexor strength differed between the Young and Old participant groups.

Results

Despite being matched for gender and BMI, the older participants displayed significantly reduced flexor strength of both the hallux and lesser toes (see Table 1). This equates to a 36% and 30% reduction in strength of the hallux and lesser toes, respectively.

Discussion and conclusion

This study confirms that the strength of the muscles that perform toe flexion is reduced in older people compared to their younger counterparts This reduction in toe flexor strength is likely to have a profound effect on the ability of older people to walk safely. For example, our previous research has found that a reduction in hallux and lesser toe strength increases the risk of falling, with each 1% BW reduction increasing the risk of falling by 7% (Mickle et al. 2009). The difference of 6.5% BW in the hallux strength between the young and old cohorts, suggests that the risk of falling is increased by approximately 45% in healthy older people relative to their younger counterparts.

There is evidence to suggest that the toe flexor muscles can respond to training, not only through traditional resistance exercises, but also through specialised footwear (Potthast et al. 2005; Munro et al. 2011). Therefore, further efforts into the research and design of functional footwear that can be targeted at restoring foot function in the growing older population should be made a priority.

Table1.Descriptive characteristics and mean toe strength of the Young & Old participant groups (SD). * Indicates a significant difference between the groups ($p \leq 0.02$).

	Young (n = 17)	**Old (n = 17)**
Age (years)	28.8 (8.2)	66.8 (2.8)*
BMI (kg.m^2)	26.0 (4.1)	26.0 (4.0)
Hallux strength (% BW)	18.2 (7.0)	11.7 (5.4)*
Toe Strength (% BW)	11.1 (3.3)	7.8 (4.4)*

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