PLANTARFLEXOR MOMENT ARM CORRELATES WITH PREFERRED GAIT VELOCITY IN HEALTHY ELDERLY SUBJECTS

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INTRODUCTION

Walking ability is a fundamental determinant of quality of life that is known to decline with advancing age. Gait velocity begins to decline at 12% to 16% per decade after the age of 70 [1] mainly through a reduction in step length [2]. Reduced walking velocity has been attributed to age-related reductions in lower extremity strength and power [3,4].

Decreased walking velocity in older adults is accompanied by decreased ankle plantarflexion range of motion, plantarflexor moment, and plantarflexor power during gait [3,4]. Judge et al. found that older adults walk faster by generating greater hip flexor power, suggesting (a) that ankle plantarflexor power cannot be increased and is thus a limiting factor in determining walking speed; and (b) that different strategies might be employed at fast and preferred walking speeds in older adults.

It is reasonable to expect that age-related decreases in triceps surae cross-sectional area contribute to reduced plantarflexor moment- and power-generating capacity, but other musculoskeletal architecture parameters have the potential to influence moment and power and thus gait velocity. Plantarflexor moment arm and muscle fascicle length are two such parameters whose influence on gait velocity has not yet been studied.

The purpose of this study was to investigate the influence of plantarflexor moment arm and plantarflexor fascicle length on both preferred and maximum gait velocity in a group of healthy elderly subjects.

METHODS

Fascicle length, pennation angle, and plantarflexion moment arm of the lateral gastrocnemius muscle were measured in 10 elderly adult males (76.1 ± 5.4 y, 174.1 ± 5.2 cm, 87.3 ± 13.6 kg). Subjects received a screening questionnaire to exclude those with a history of stroke, heart attack, arthritis, and joint surgery. None of the subjects reported any muscular or joint injuries in the year prior to testing. All subjects gave informed consent prior to testing and all procedures were approved by the Institutional Review Board of the University.

Fascicle length and pennation angle were determined from images captured using B-mode ultrasonography (Aloka 1100; transducer: SSD-625, 7.5 MHz). Images of the central region of the muscle were obtained while the subjects were standing in anatomical position.

Plantarflexor moment arm was calculated from tendon excursion measured from ultrasound images and measured foot rotations. In these tests, the foot was rotated manually by an experimenter from approximately 5º dorsiflexion to 20º plantarflexion using a potentiometer-instrumented rotating foot platform while a second experimenter captured ultrasound images of the musculotendinous junction. During these tests, the subject was seated with the knee fully extended and the subject plantarflexed maximally against the foot platform in order to minimize artifact resulting from variation in tendon tension during movement [5]. Moment arm was estimated as the slope of the line fit to the tendon excursion versus ankle angle data.

Preferred walking speed was determined using the Six-Minute Walk Test [6], in which the subject was asked to walk at a preferred pace for six minutes along a level walkway between two cones spaced 50 m apart. Maximum walking velocity was assessed during tests in which subjects were asked to walk 4 m as fast as possible.

RESULTS

A moderate and significant correlation ($R^2 = 0.48$, $p = 0.026$) was found between plantarflexion moment arm and preferred walking velocity but no significant correlation ($R^2 = 0.13$, $p = 0.312$) was found between plantarflexion moment arm maximum velocity (Figure 1). No significant correlations were found between lateral gastrocnemius fascicle length and preferred walking velocity ($R^2 = 0.20$, $p = 0.193$) or maximum walking velocity ($R^2 = 0.10$, $p = 0.382$) (Figure 2). Neither walking velocity (preferred or maximum) nor plantarflexor moment arm was found to correlate with body height (all $R^2 \leq 0.21$; $p > 0.05$).

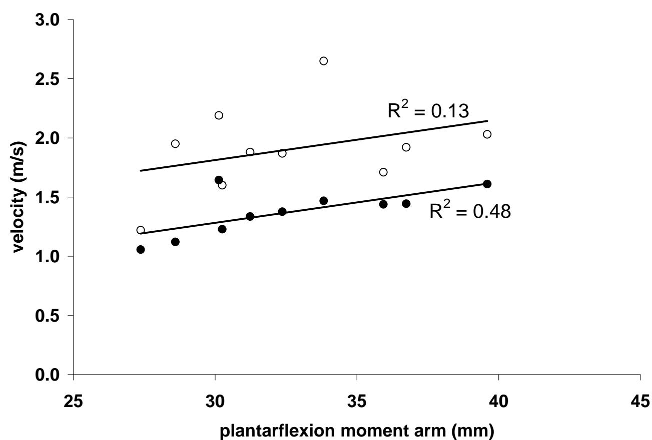

Figure 1. Preferred walking velocity (filled circles) and maximum velocity (open circles) plotted versus plantarflexion moment arm.

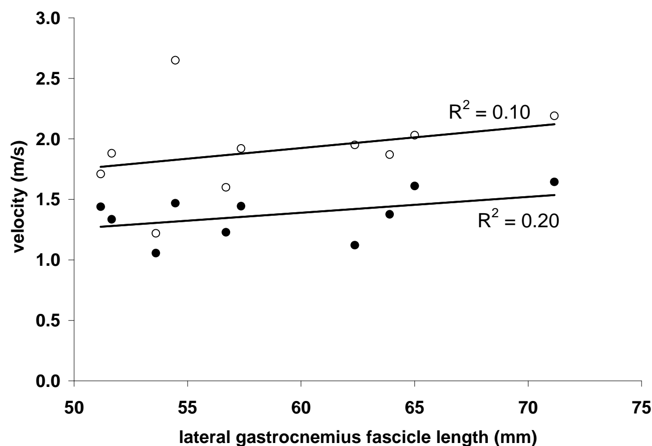

Figure 2. Preferred walking velocity (filled circles) and maximum velocity (open circles) plotted versus lateral gastrocnemius fascicle length.

DISCUSSION

Preferred walking velocity was found to correlate with plantarflexor moment arm, but this was not the case for maximum walking velocity. This finding suggests that age-related reduction in step length at the preferred velocity depends to some extent on the mechanical advantage of the plantarflexor muscles but that this dependence vanishes when subjects are asked to walk fast, perhaps because of increasing reliance on another mechanism, such as the hip flexors, to increase step length [3].

Bean et al. [6] found Six-Minute Walk Test performance to correlate moderately with ankle power ($R^2 = 0.37$) and ankle strength ($R^2 = 0.24$) in isokinetic and isometric dynamometer tests in a mobility-limited population. Our findings suggest that plantarflexor moment arm is an even better predictor of preferred gait speed, perhaps because maximal moments are were not generated during preferred walking in our healthy elderly subjects. A likely mechanism is that a larger plantarflexion moment arm permits a subject to take a longer step and that the importance of having a sufficient moment arm is increased when muscle mass is lost with aging.

CONCLUSIONS

Plantarflexor moment arm is moderately correlated with walking velocity in healthy elderly subjects. This finding that mechanical advantage is a potentially important determinant of locomotor ability in the elderly will help with designing and targeting interventions intended to preserve mobility in this population.

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