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Published in final edited form as:
J Biomech. 2014 March 21; 47(5): 1104–1109. doi:10.1016/j.jbiomech.2013.12.024.

Healthy Older Adults Have Insufficient Hip Range of Motion and Plantar Flexor Strength to Walk Like Healthy Young Adults

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Abstract

Limited plantar flexor strength and hip extension range of motion (ROM) in older adults are believed to underlie common age-related differences in gait. However, no studies of age-related differences in gait have quantified the percentage of strength and ROM used during gait. We examined peak hip angles, hip torques and plantar flexor torques, and corresponding estimates of functional capacity utilized (FCU), which we define as the percentage of available strength or joint ROM used, in ten young and ten older healthy adults walking under self-selected and controlled (slow and fast) conditions. Older adults walked with about 30% smaller hip extension angle, 28% larger hip flexion angle, 34% more hip extensor torque in the slow condition, and 12% less plantar flexor torque in the fast condition than young adults. Older adults had higher FCU than young adults for hip flexion angle (47% vs. 34%) and hip extensor torque (48% vs. 27%). FCUs for plantar flexor torque (both age groups) and hip extension angle (older adults in all conditions; young adults in self-selected gait) were not significantly <100%, and were higher than for other measures examined. Older adults lacked sufficient hip extension ROM to walk with a hip extension angle as large as that of young adults. Similarly, in the fast gait condition older adults lacked the strength to match the plantar flexor torque produced by young adults. This supports the hypothesis that hip extension ROM and plantar flexor strength are limiting factors in gait and contribute to age-related differences in gait.

Keywords

Aging; Walking; Physical Function; Speed; Step Length

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Conflict of interest statement: The authors have no conflict of interest.

1. Introduction

Commonly reported age-related differences in gait may arise from physiological or neuromuscular limitations in older adults (McGibbon, 2003; Winter et al., 1990). Two particular impairments that may contribute to age-related differences in gait are reduced plantar flexor strength and reduced hip extension range of motion (ROM) (McGibbon, 2003). Many studies have reported reduced plantar flexor kinetics (e.g. peak torque, power generation and work) in older adults during gait (DeVita and Hortobagyi, 2000; Judge et al., 1996; Kerrigan et al., 1998; Monaco et al., 2009; Riley et al., 2001; Silder et al., 2008; Winter et al., 1990), which could be caused by reduced plantar flexor strength. Older adults may compensate for reduced plantar flexor kinetics with increased hip extensor power and work (DeVita and Hortobagyi, 2000; Monaco et al., 2009; Silder et al., 2008), or alternatively with increased hip flexor power and work in late stance (Cofre et al., 2011; Goldberg and Neptune, 2007; Judge et al., 1996; Monaco et al., 2009). In addition to kinetic differences, a number of studies have reported that older adults walk with a smaller peak hip extension angle than young adults (Kerrigan et al., 2001; Kerrigan et al., 1998; Lee et al., 2005; Monaco et al., 2009), possibly due to reduced hip extension ROM. Supporting this, a hip flexor stretching program that increased hip extension ROM in older adults also increased peak hip extension angle and step length during gait (Watt et al., 2011). Overall, previous studies suggest the hypothesis that older adults walk with lower plantar flexor peak torque and the hip more flexed than young adults because of limitations in plantar flexor strength and hip extension ROM, respectively. A few studies have examined the percentage of available strength used during level walking, calling it “muscular utilization ratio” (Nadeau et al., 1996, 1999; Requiao et al., 2005) or “functional demand” (Samuel et al., 2013). However, no previous studies have evaluated the percentage of strength or ROM used by healthy young and older adults, and whether these are in fact limiting factors that give rise to age-related differences in gait. Thus, this study examines the percentage of available strength and hip joint ROM, which we term functional capacity utilized (FCU), used by healthy young and older adults in level walking, in order to gain insight into the limitations underlying age-related differences in gait.

Most studies reporting differences in gait kinetics between young and older adults have also reported differences in speed and/or step length (DeVita and Hortobagyi, 2000; Judge et al., 1996; Kerrigan et al., 1998; Monaco et al., 2009; Riley et al., 2001; Winter et al., 1990). This may confound age differences in kinetics, as gait kinetics are affected by both speed (Graf et al., 2005; Kerrigan et al., 1998) and step length (Allet et al., 2011). Several studies have matched gait speed between age groups (Cofre et al., 2011; DeVita and Hortobagyi, 2000; Monaco et al., 2009), but older adults may still walk with shorter step length and higher cadence than young adults. When speed and step length do not differ between age groups, age differences remain in gait kinetics (Silder et al., 2008), indicating that age differences arise from factors besides older adults choosing a different speed and step length. However, to understand how functional impairments affect age differences in gait, it may be necessary to control both speed and step length to prevent confounding by common age differences in spatio-temporal characteristics. Thus to account for the effects of both speed and step length, this study examines controlled gait with fixed speeds and step length in addition to self-selected gait.

2. Methods

2.1 - Participants

Ten young (ages 20-31) and ten older (ages 75-86) healthy adult volunteers participated in functional testing and gait testing (Table 1). Participants could walk independently and reported no musculoskeletal, neurological, cardiovascular, or cognitive disorders that might affect gait. The study was approved by the Virginia Tech Institutional Review Board, and all participants provided written informed consent.

2.2 – Measurement

During functional testing, maximum isometric joint torques in hip extension, hip flexion, and plantar flexion, as well as hip extension and hip flexion ROM were measured on the right lower extremity using a Biodex System 3 dynamometer (Biodex Medical Systems, Inc., Shirley, New York, USA). Plantar flexion testing was performed with the standard manufacturer attachment, while hip testing was performed in an upright position with the body stabilized in a custom-built frame and the knee immobilized at about 0° of knee flexion. Maximum isometric joint torque was measured as the largest of three or more maximum voluntary exertions performed at the approximate joint angles at which maximum isometric joint torques occur (Anderson et al., 2007). If a participant's joint ROM was less than the target angle, strength was tested at the limit of the ROM. Specifically, hip extension torque was tested at a target angle of 68° of hip flexion (ROM limited to 56°, 60°, 60°, 60°, 62°, 62° and 65° respectively in seven participants), hip flexion torque was tested at a target angle of 15° of hip extension (ROM limited to 11° and 13° respectively in two participants), and plantar flexion torque was tested at a target angle of 26° of dorsiflexion (ROM limited to 23° in one participant). Joint torque and angle were recorded at 200 Hz and low pass filtered at 5 Hz (Anderson et al., 2007) to attenuate electromechanical noise in the data. Prior to strength testing, each joint was passively moved through two full cycles of joint motion at 5 °/s while participants remained relaxed, and this data was used to correct strength measurements for gravitational moments and model passive elastic joint torques (Anderson et al., 2010). Hip ROMs were determined by manually moving the hip joint to the participant's limits of motion.

Each participant performed gait trials on an 8 m long walkway under self-selected and controlled (slow and fast) conditions. Participants practiced each condition until comfortable with the task prior to recording data. First, a single trial of self-selected gait was recorded, followed by slow and fast conditions presented in random order. Target speeds (slow: 1.1 m/s; fast: 1.5 m/s), and step length (0.65 m for both speeds) were representative of values reported in the literature for self-selected gait in young and older adults (Judge et al., 1996; Kerrigan et al., 1998; Silder et al., 2008; Winter et al., 1990). A moving belt beside the walkway and stripes painted across walkway provided cues of target speed and step length, respectively. Trials were repeated if estimated speed was not within 5% of the target speed. Ground reaction forces were sampled at 1000 Hz from a six degree-of-freedom force platform (Advanced Mechanical Technology Inc., Watertown, MA, USA) in the center of the walkway. Kinematics were determined from four reflective markers on each foot, five on each shank, five on each thigh, four on the pelvis, and four on the upper body sampled at 100 Hz using a six-camera VICON 460 motion analysis system (VICON Motion Systems Inc., Lake Forest, CA, USA).

2.3 – Data processing

The model of Delp et al. (Delp et al., 1990) was adapted to create an individualized, eight segment, 27 degree-of-freedom, model of the upper body, pelvis and lower extremities for each participant in OpenSim (Delp et al., 2007). Anthropometry measurements were used to estimate segment masses, center of mass locations and mass moments of inertia (de Leva, 1996; Pavol et al., 2002). Joint center positions were determined by functional methods (Piazza et al., 2004) and data from a calibration trial in which each participant moved each joint through its degrees of freedom.

Speed and step length were evaluated from marker data, and one trial best representing the desired speed and step length was selected for each controlled gait condition. Ground reaction forces and marker motion data were low pass filtered at 7 Hz and center of pressure position was determined (Winter, 2005). Inverse kinematics and 3D inverse dynamics were performed in OpenSim to estimate internal joint torques over one full swing and stance cycle of the right lower extremity.

Primary variables of interest during gait were peak hip extension angle (HEA), peak hip flexion angle (HFA), total hip angular excursion (THA), peak hip extension torque (HET), peak hip flexion torque (HFT) and peak plantar flexion torque (PFT) (Figure 1). For hip angles, FCU was calculated as:

$$\mathrm{FCU}=\frac{A}{R}\times 100 \quad \text{(Equation 1)}$$

where *A* is the hip angle of interest during gait (HEA, HFA or THA), and *R* is the corresponding measured ROM (hip extension ROM, hip flexion ROM, or total hip ROM, respectively). For joint torques, FCU was calculated as:

$$\mathrm{FCU}=\frac{T}{S+P}\times 100 \quad \text{(Equation 2)}$$

where *T* is the peak joint torque of interest during gait (HET, HFT or PFT), and *S* and *P* are the corresponding active and passive components of available joint strength, respectively. *S* was determined by adjusting measured isometric torque for joint angle and angular velocity at the time of peak joint torque using a model relating joint torque, angle and angular velocity (Anderson et al., 2007). Specifically:

$$S=\begin{cases} S_{ISOMETRIC}\cos\left(C_2\left(\theta-C_3\right)\right)\left(\frac{2C_4C_5+\dot{\theta}(C_5-3C_4)}{2C_4C_5+\dot{\theta}(2C_5-4C_4)}\right) & \dot{\theta}\geq 0\\ S_{ISOMETRIC}\cos\left(C_2\left(\theta-C_3\right)\right)\left(\frac{2C_4C_5-\dot{\theta}(C_5-3C_4)}{2C_4C_5-\dot{\theta}(2C_5-4C_4)}\right)\left(1-C_6\,\dot{\theta}\right) & \dot{\theta}<0 \end{cases} \quad \text{(Equation 3)}$$

where $S_{ISOMETRIC}$ is measured maximum isometric joint torque, θ is joint angle at the time of peak torque, and $\dot{\theta}$ is joint angular velocity at the time of peak torque. Values of the coefficients C_2 – C_6 were taken from the literature based on participant age and sex (Anderson et al., 2007). Passive joint torque *P* was determined using the model:

$$\mathrm{P}=B_1e^{k_1}\theta+B_2e^{k_2}\theta \quad \text{(Equation 4)}$$

with coefficients *B* and *k* determined from passive motion data as previously described (Anderson et al., 2010). Measurement errors were found in hip ROM data for one participant and plantar flexor strength for two participants, and these values were imputed based on age and sex when calculating FCUs.

2.4 – Statistical Analysis

Body mass, height, hip ROM and maximum isometric joint strength were examined for differences between age groups using unpaired t-tests (α=0.05). Similarly, gait speed, step length, cadence and stance time were examined for differences between age groups within each gait condition. Outcome variables (peak angles, peak torques and FCUs) were examined using two-factor (age group and gait condition) mixed-model ANOVAs (α=0.05). If there was evidence of an age × gait condition interaction ($p \leq 0.10$), age differences within each gait condition were examined in post-hoc *t*-tests. Otherwise the interaction term was dropped from the model and the main effect of age examined. To further examine whether strength or ROM was limiting gait, one sample *t*-tests for the means were performed for individual FCUs to determine if they were <100%. To evaluate if the FCU variables were different from each other, the FCU data was pooled for all age groups and gait conditions, and paired t-tests were performed for each FCU pair.

Because we examined age differences for six primary outcome variables, and six corresponding FCUs in three gait conditions, as well as the means of and differences between the six FCUs, it was necessary to adjust the level of significance to control the Type 1 error rate. However, the statistical comparisons made were not independent as many of the outcome variables were correlated with each other. Principal components analysis (PCA) allows sets of correlated variables to be reduced to a set of uncorrelated variables (principal components) that capture as much of the variation in the data as possible. Previous studies using PCA to reduce gait data sets have used the number of principal components required to explain ≥90% of the variation in the data (Deluzio and Astephen, 2007; Reid et al., 2010). Thus, we estimated the number of independent outcomes being examined, *n*, as the number of principal components explaining ≥90% of the variation in the outcome variables, and adjusted significance was defined as $\alpha=0.05/n$. Statistical analyses were performed using the software JMP (SAS Institute, Inc., Cary, NC, USA).

3. Results

Older adults were not different from young adults in body mass or height, but had lower hip extension ROM, total hip ROM, and maximum isometric joint torques than young adults (Table 1). Step length was 8% smaller for older adults in self-selected gait, but there were no age differences in spatio-temporal characteristics in controlled gait (Table 2). Based on PCA, seven principal components accounted for >90% of the variation in the outcome variables. Thus, adjusted significance for age differences in outcome variables and comparisons of FCUs was set at $\alpha = 0.05/7 = 0.007$.

Older adults averaged about 30% less HEA than young adults across all gait conditions ($p < 0.001$), but the FCU for HEA was not different between age groups (Figure 2). Both HFA and THA showed age × gait condition interactions ($p < 0.10$), as did the FCUs for HFA and THA, and age differences were examined for each gait condition separately. In post-hoc tests, HFA was 21-33% larger in older adults than young adults in all three gait conditions ($p < 0.007$), but THA was not different between age groups in any gait condition. Similarly, older adults used on average about 11-14% more of their functional capacity for HFA than young adults ($p < 0.007$), but FCU for THA was not different between age groups in any gait condition.

HET and PFT showed age × gait condition interactions ($p < 0.10$), and age differences were examined for each gait condition separately. Older adults produced about 34% more HET than young adults in the slow condition ($p < 0.007$), but there were no age differences in self-selected or fast conditions (Figure 3). However, older adults used about 21% more of their functional capacity for HET than young adults across all three gait conditions ($p < 0.001$). Older adults produced about 12% less PFT than young adults in the fast condition ($p = 0.003$), but there were no age differences in self-selected or slow conditions, nor were there age differences in FCU for PFT in any gait condition. There were no significant age differences in HFT or in functional capacity for HFT.

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FCU for PFT was not <100% ($p > 0.007$) in all gait conditions for both young and older adults. Similarly, FCU for HEA was not <100% ($p > 0.007$) in all gait conditions for older adults, and in self-selected gait in young adults, but FCU for HEA was <100% in slow and fast controlled gait in young adults ($p < 0.007$). All FCUs examined for HET, HFT, HFA and THA were < 100% ($p < 0.007$) in both age groups. The mean FCU for PFT (older: 99%; young: 86%) and HEA (older: 86%; young: 76%) was significantly higher than for the other measures examined in both age groups ($p < 0.001$, Figure 4). In older adults, about 50% of functional capacity was used for THA, HET, and HFA, although FCU for THA was higher than FCU for HFA (54% vs. 47%). Older adults used 37% of HFT capacity during gait, significantly lower than all other FCUs examined. Young adults used 45% of THA capacity, higher than for HFA, HFT, and HET. In young adults, about 30% of functional capacity was used for HFA, HFT, and HET, although FCU for HFA was higher than FCU for HET (34% vs. 27%).

4. Discussion

The purpose of this study was to examine gait in healthy young and healthy older adults, and whether limitations in strength and hip ROM are likely to contribute to age-related differences in gait. Both age groups used a majority of their available plantar flexor strength and hip extension ROM during gait, significantly more than the available capacity used for other measures examined. This suggests that even small reductions in plantar flexor strength or hip extension ROM could alter gait. In fact, older adults lacked sufficient hip extension ROM to walk with a hip extension angle as large as that of young adults. Similarly, in the fast gait condition older adults lacked the strength to match the plantar flexor torque produced by young adults. Overall, our results support the hypothesis that reduced hip extension ROM and plantar flexor strength in older adults contribute to age-related differences in gait, although a definitive cause-and-effect relationship cannot be concluded from the cross-sectional study performed here.

The overall mean FCUs in the current study were 92% for PFT, 34% for HFT and 38% for HET, compared to 57%, 36% and 29%, respectively, reported by Requaio et al. (2005) for middle-aged adults. The differences, particularly for plantar flexors, are likely due to methodological differences in the studies, including higher average gait speed in the current study and different approaches to account for joint angle and angular velocity during gait. By contrast, Samuel et al. (2013) reported FCUs of 68% for HFT and 127% for HET in healthy older adults. These much higher FCUs appear to be due to comparatively lower measures of hip strength.

Older adults walked with smaller HEA and larger HFA than young adults, consistent with previous studies (DeVita and Hortobagyi, 2000; Kerrigan et al., 2001; Kerrigan et al., 1998; Lee et al., 2005; Monaco et al., 2009). FCU for HEA was not <100% in self-selected gait in both age groups, suggesting that the majority of hip extension ROM is typically used during gait. FCU was <100% for young adults in controlled gait, perhaps due to artificially limited step length, but it remained not <100% in older adults. Overall, the HEA exhibited by young adults (mean 20.3°) slightly exceeded the hip extension ROM of older adults (mean 19.7°), indicating that older adults did not have sufficient hip ROM to walk like young adults. This supports the hypothesis that age-related differences in gait arise from reduced hip extension ROM in older adults (Kerrigan et al., 2001; Kerrigan et al., 1998; Lee et al., 2005; Watt et al., 2011).

Older adults walked with lower PFT than young adults in the fast gait condition, although no age differences were found in other conditions (Figure 3). This age difference is generally consistent with previous reports (DeVita and Hortobagyi, 2000; Judge et al., 1996; Kerrigan et al., 1998; Monaco et al., 2009; Riley et al., 2001; Silder et al., 2008; Winter et al., 1990). In particular, Silder et al. (2008) found age differences in plantar flexor power and work at fast speeds but not slower speeds, similar to our results. Estimated FCU for PFT was not significantly <100% for either age group, indicating little or no capacity to increase PFT during gait. However, in the fast gait condition the PFT of young adults (mean 1.53 N-m/kg) exceeded the available plantar flexor strength of older adults (mean 1.36 N-m/kg), indicating that older adults did not have sufficient strength to walk like young adults. This supports the hypothesis that older adults exhibit reduced plantar flexor kinetics during gait as a result of plantar flexor weakness (DeVita and Hortobagyi, 2000; Judge et al., 1996; Silder et al., 2008).

Older adults walked with higher HET in the slow condition, consistent with previous findings of greater hip extension angular impulse, power and work in older adults compared to young adults (DeVita and Hortobagyi, 2000; Monaco et al., 2009; Silder et al., 2008). Estimated FCUs were relatively low and significantly <100% for HET and HFT in both young (24-36%) and older (34-54%) adults. Thus, although older adults exhibited higher HET FCUs than young adults, they retained significant capacity to increase both HET and HFT. However, our results do not support the common hypothesis that older adults increase hip extensor kinetics to compensate for reduced plantar flexor kinetics (DeVita and Hortobagyi, 2000; Silder et al., 2008), as age differences in HET and PFT were not observed simultaneously in the same gait condition. An alternative explanation is that older adults increase HET to counteract a larger hip flexion angle at the time of HET, but further study is needed to examine this theory.

Age differences in peak joint torques varied between gait conditions, with no differences in self-selected gait, but differences in HET during slow gait and PFT during fast gait. Self-selected and slow gait were similar in speed and step length, but there was a significant age difference in step length in self-selected gait. This may indicate that differences in step length may produce, or conceal, age-related differences in gait kinetics. Furthermore, the age differences found for both HET and PFT varied between slow and fast gait, even with speed and step length matched between age groups. Thus, gait speed can profoundly affect age-related differences in gait kinetics, even when controlling for step length. Overall, these results support the findings of previous studies that gait kinetics are affected by both speed and step length (Allet et al., 2011; Graf et al., 2005; Kerrigan et al., 1998), and indicate the need to account for both speed and step length when examining age-related differences in gait kinetics.

Several limitations to this study should be noted. First, participants in this study were healthy, community-dwelling, and able to walk independently, limiting the ability to generalize the results to other populations. Second, estimated FCU is susceptible to errors in both gait analysis and functional measurements, as evidenced by FCUs exceeding 100% in some cases. Third, we measured only isometric joint torques in evaluating strength. Because it is important that functional measures of strength match the instantaneous joint angle and angular velocity found during gait (Nadeau et al., 1996; Requiao et al., 2005), and because passive-elastic joint properties may contribute significantly to joint kinetics (Silder et al., 2008), we adjusted available joint strength for joint kinematics and passive elastic joint torques, but these adjustments could also introduce errors in FCU estimates. Fourth, we estimated FCUs at the time of peak torque or hip angle. However, peak FCU for joint torque may not necessarily coincide temporally with the instant of peak joint torque due to variations in strength with joint angle and angular velocity (Bieryla et al., 2009). Finally, this study examined only peak joint torques as kinetic measures, corresponding to the functional measures of strength. However, age differences in other kinetic measures, particularly joint peak power generation and work, are often reported during walking (Cofre

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et al., 2011; DeVita and Hortobagyi, 2000; Judge et al., 1996; Kerrigan et al., 1998; Monaco et al., 2009; Riley et al., 2001; Silder et al., 2008; Winter et al., 1990). Several studies indicate that leg power is more strongly related to physical function and gait speed in older adults than strength (Bean et al., 2010; Bean et al., 2003; Puthoff and Nielsen, 2007). Thus, additional insight into age-related changes in gait might be gained by measuring maximal joint power and applying the concept of FCU to joint power during gait.

The primary strength of this study is its combination of gait analysis with corresponding measures of functional capacity to study age-related differences in gait. The results provide unique empirical evidence supporting the idea that plantar flexor strength and hip extension ROM are limiting factors in gait, and support the use of similar approaches in future work. This study also uniquely controls for both speed and step length during gait, and indicates the potential importance of accounting for both of these spatio-temporal effects when examining age-related differences in gait.

Acknowledgments

We thank Serkalem Demissie, Ph.D., Boston University School of Public Health, for providing statistical advice. This work was supported by grants from the National Institute on Aging (F31-AG030904; T32-AG023480). The study sponsors had no role in the study design, data collection, analysis, manuscript preparation, or the decision to submit the manuscript for publication.

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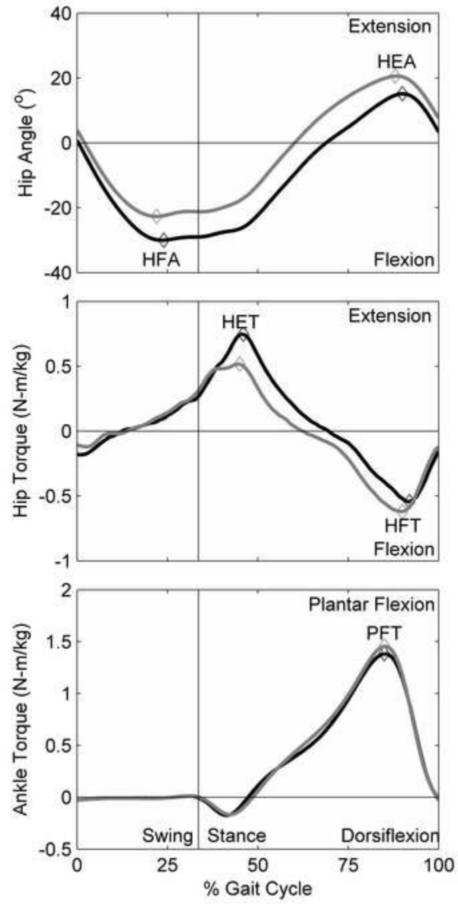

Figure 1.

Hip angles and hip and ankle torques (normalized by body mass) averaged across all subjects for young (gray line) and older (black line) age groups throughout a single gait cycle of the slow gait condition (with both speed and step length controlled). Peak hip angles and peak joint torques indicated by diamonds, and the corresponding functional capacities utilized, were analyzed for age differences.

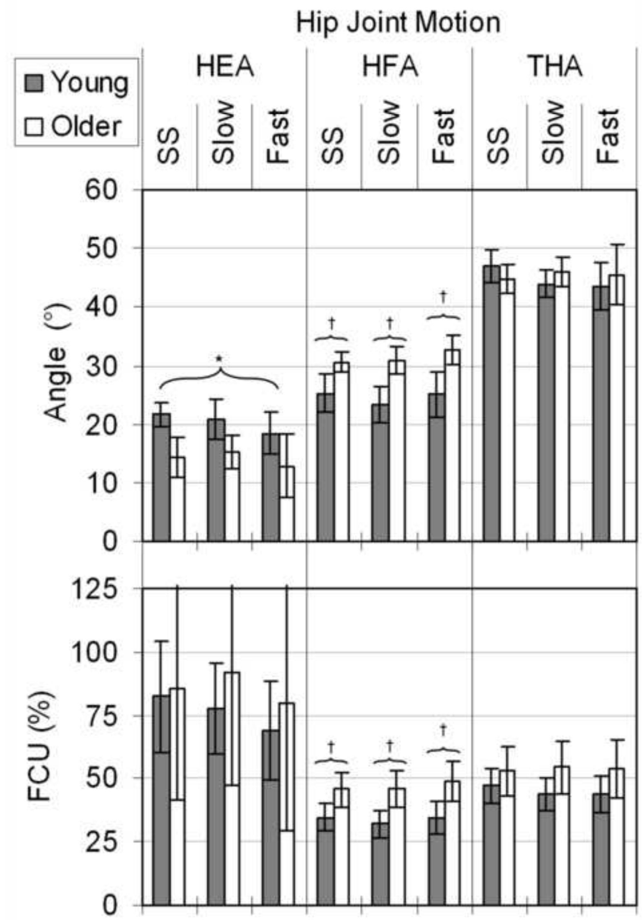

Figure 2.
Peak hip extension angle (HEA), peak hip flexion angle (HFA), and total hip angular excursion (THA) during self-Selected (SS), Slow, and Fast gait, presented in terms of actual angle (top) and corresponding percent functional capacity utilized (FCU - bottom). *Significant main effect of age across all gait conditions ($p < 0.007$); †Significant effect of age within gait condition ($p < 0.007$).

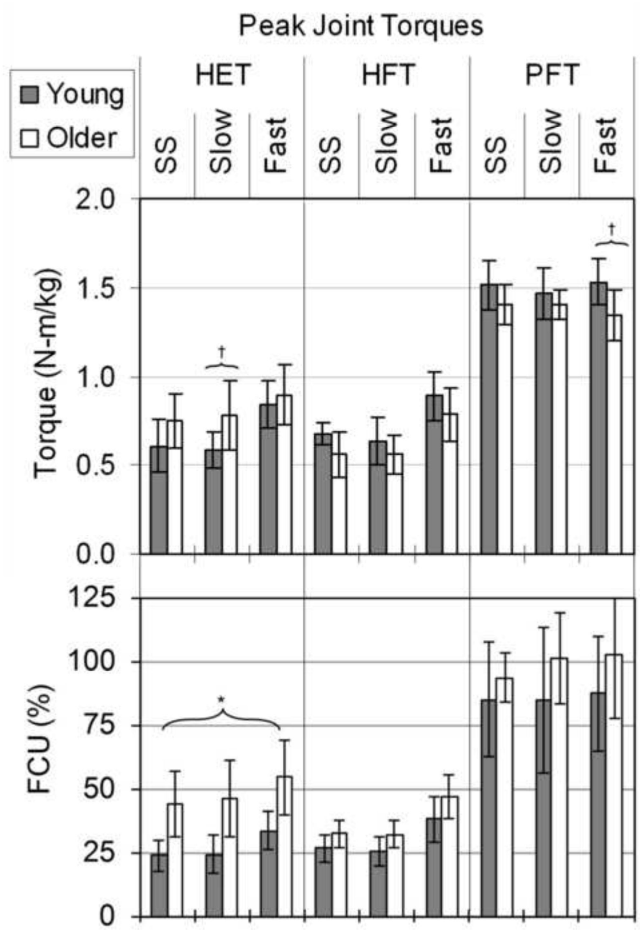

Figure 3.
Peak lower extremity joint torques during self-selected (SS), slow, and fast gait presented in terms of torque normalized by body mass (top) and corresponding percent functional capacity utilized (FCU - bottom). *Significant main effect of age across all gait conditions ($p < 0.007$); †Significant effect of age within gait condition ($p < 0.007$).

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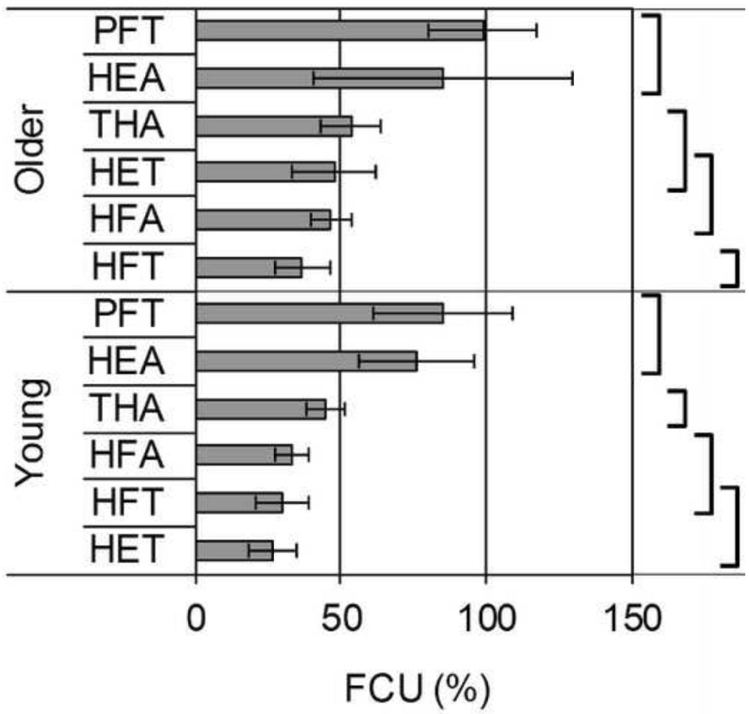

Figure 4.
Mean functional capacities utilized (FCUs) combined across all three gait conditions by age group. Within each age group, FCUs are arranged in descending order, and, FCUs not connected by a common bracket are significantly different from each other ($p < 0.007$). Note that order of FCUs is different for each age group.

Table 1

Mean (SD) subject characteristics and functional measures by age group. Maximum isometric joint torques are normalized by body mass. Hip extension and flexion ROMs were measured relative to the anatomical position.

	Young (N=10)	**Older (N=10)**	**% Difference**
Age (years)	23.9 (3.3)	80.3 (4.0)	
Sex (M/F)	5/5	5/5	
Body mass (kg)	61.7 (7.3)	65.2 (10.5)	6%
Height (m)	1.65 (0.09)	1.63 (0.08)	0%
Hip ROM (°):			
Extension	28.0 (7.8)	19.7 (5.2)	−30%[a]
Flexion	73.5 (8.4)	69.1 (10.9)	−6%
Total	101.5 (13.9)	87.1 (15.2)	−14%[a]
Maximum Isometric Joint Torque (N-m/kg):			
Hip Extension	4.51 (0.94)	3.02 (0.85)	−33%[a]
Hip Flexion	2.67 (0.51)	1.76 (0.23)	−34%[a]
Plantar Flexion	2.64 (0.59)	2.12 (0.25)	−20%[a]

[a]Significant age difference ($p < 0.05$).

Table 2

Mean (SD) values of spatio-temporal characteristics of gait by age group and gait condition.

	Age	Self-selected	Slow controlled	Fast controlled
Speed (m/s)	Older	1.19 (0.12)	1.18 (0.04)	1.53 (0.05)
	Young	1.26 (0.10)	1.18 (0.02)	1.52 (0.04)
Step Length (m)	Older	0.65 (0.05)	0.65 (0.01)	0.65 (0.01)
	Young	0.70 (0.04)[a]	0.65 (0.004)	0.66 (0.01)
Cadence (steps/min)	Older	110 (10)	110 (5)	141 (6)
	Young	108 (6)	109 (2)	139 (4)
Stance Time (%)	Older	66.7 (1.4)	66.0 (1.5)	66.7 (1.1)
	Young	66.0 (1.3)	66.8 (1.7)	67.0 (0.8)

[a]Significant age difference within gait condition ($p = 0.010$).