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Age-related differences in the maintenance of frontal plane dynamic stability while stepping to targets

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Abstract

Older adults may be vulnerable to frontal plane dynamic instability, which is of clinical significance. The purpose of the current investigation was to examine the age-related differences in frontal plane dynamic stability by quantifying the margin of stability and hip abductor moment generation of subjects performing a single crossover step and sidestep to targets that created three different step widths during forward locomotion. Nineteen young adults (9 males, age: 22.9±3.1 years, height: 174.3±10.2 cm, mass: 71.7±13.0 kg) and 18 older adults (9 males, age: 72.8±5.2 years, height: 174.9±8.6 cm, mass: 78.0±16.3 kg) participated. For each walking trial, subjects performed a single laterally-directed step to a target on a force plate. Subjects were instructed to "perform the lateral step and keep walking forward". The peak hip abductor moment of the stepping limb was 42% larger by older adults compared to younger adults (p<0.001). Older adults were also more stable than younger adults at all step targets (p<0.001). Older adults executed the lateral step with slower forward-directed and lateral-directed velocity despite similar step widths. Age-related differences in hip abduction moments may reflect greater muscular effort by older adults to reduce the likelihood of becoming unstable. The results of this investigation, in which subjects performed progressively larger lateral-directed steps, provide evidence that older adults may not be more laterally unstable than younger adults. However, age-related differences in this study could also reflect a compensatory strategy by older adults to ensure stability while performing this task.

Keywords

Biomechanics; Gait; Lateral steps; Hip moment; Center of mass control

1. Introduction

Previous investigations have suggested older adults may be vulnerable to frontal plane dynamic instability (Hall and Jensen, 2002; Hilliard et al., 2008; Maki et al., 2000; McIlroy

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Conflict of interest statement

Mark D. Grabiner has no conflicts of interest to declare with regard to the present study.

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and Maki, 1996; Mille et al., 2005), which is of clinical significance. A degraded ability to maintain control of frontal plane center of mass (COM) motion with respect to the base of support (BOS) could increase fall risk. The extent to which disturbances to lateral balance while walking relate to the ability of healthy older adults to maintain frontal plane dynamic stability is not known.

Frontal plane dynamic stability is highly regulated on a step-by-step basis while walking (Hof et al., 2007; Hurt et al., 2010; Rosenblatt and Grabiner, 2010). Swing foot placement establishes a distance between the COM and the base of support, creating the initial conditions to control frontal plane COM motion (i.e., COM position and velocity) and ultimately frontal plane dynamic stability. After heelstrike, hip abductor moment generation during the stance phase decelerates the laterally-directed COM motion and redirects the COM medially (MacKinnon and Winter, 1993; Pandy et al., 2010). For normal walking conditions, compensation for deficiencies in control of COM kinematics may occur on a step-to-step basis to allow for safe community ambulation (Schrager et al., 2008). Thus, assessing the robustness of the central nervous system to control COM motion requires that tasks must create a greater challenge to dynamic stability compared to undisturbed walking.

Laterally-directed steps are commonly utilized while walking in the community to circumvent obstacles or to avoid undesirable step locations. These laterally-directed steps require an increased displacement and velocity of the COM that must then be arrested and reversed if the previous direction of travel (i.e., forward) is to be regained. Manipulating the spatial aspects of the step (i.e., lateral step distance) scales the difficulty of the task due to the larger lateral velocity. This may be more difficult for older adults given the significant reduction in peak isometric and isokinetic abductor moment production compared to younger adults (Johnson et al., 2004). Laterally-directed steps represent a functional task that requires both muscular strength and power to ensure frontal plane dynamic stability is maintained.

Two lateral-step strategies have been identified as compensatory stepping responses to external postural disturbances (Hurt et al., 2011; Maki et al., 2000), but can also be performed while walking. One is a sidestep (SS) in which the stepping limb moves ipsilateral to the step direction. The second is a crossover step (COS), in which the stepping limb crosses in front of the stance limb and extends laterally away from the midline of the body. These step strategies can also be utilized to perform a lateral step while walking, and thus represent a task with ecological validity. The purpose of the current investigation was to examine the age-related differences in frontal plane dynamic stability by examining the margin of stability (Hof et al., 2005) and hip abductor moment generation of subjects performing a single COS and SS to targets that created three different step widths during forward locomotion. This provided a graded challenge to frontal plane stability. Due to the aforementioned decrease in peak ab/adductor strength and power of older adults compared to younger adults (Johnson et al., 2004), we hypothesized we would observe a significantly smaller peak abduction moment by older adults compared to younger adults during the stance phase of the lateral step, particularly at the longer step targets. Similarly, we hypothesized older adults would be less dynamically stable at heelstrike, while performing

COS and SS than younger adults, particularly at the longer step targets for which the largest abduction moments would be expected.

2. Materials and methods

Nineteen young adults (9 males, 10 females, age: 22.9±3.1 years, height: 174.3±10.2 cm, mass: 71.7±13.0 kg) and 18 older adults (9 males, 9 females age: 72.8±5.2 years, height: 174.9±8.6 cm, mass: 78.0±16.3 kg) volunteered to participate in this study. Subjects were excluded from participation if they affirmed any neurological, musculoskeletal, or other injuries or disorders that would limit their functional mobility. Older adults were also excluded if they required an assistive device to walk or if the bone mineral density of their left proximal femur was less than 0.65 g/cm^2 (Cummings et al., 1993), as measured using dual energy X-ray absorptiometry (Hologic QDR 1000, Waltham, Mass., USA). All subjects provided written informed consent prior to participation in this institutionally reviewed and approved study. Self-ratings of general health were assessed by the physical functioning subsection of the Medical Outcome Survey 36-item short form health survey (Ware and Sherbourne, 1992).

Subjects walked along an eight meter carpeted walkway (Fig. 1) and performed a single COS or a SS, with their dominant limb to targets placed at three locations on a force plate imbedded in the walkway surface (Fig. 1). Limb dominance was assessed with the Revised Waterloo Footedness Questionnaire (Elias et al., 1998). Subjects initially performed five normal walking trials. They then performed five trial each of SS and COS trials at each of the short, long and medium distances, which were performed in the same order for all subjects. A demonstration of the steps was provided by the investigator. Subjects were instructed to “perform the lateral step and keep walking forward”. The instructions ensured that individuals would keep walking forward after performing the lateral step requiring them to arrest the lateral motion thus providing a greater challenge to frontal plane dynamic stability.

The motions of 22 passive reflective markers were recorded by an eight-camera motion capture system recording at 120 Hz (Motion Analysis, Santa Rosa, CA) and filtered using a 6 Hz zero-lag low-pass Butterworth filter. The three-dimensional marker positions were tracked using commercial software (Cortex, Motion Analysis, Santa Rosa, CA), and analyzed off-line using custom Matlab software (MathWorks, Natick, MA). Kinematic variables were quantified from a twelve-segment model generated from the three-dimensional marker positions. The position of each subject’s COM was calculated using anthropometric estimations (Winter, 2005). Step width was calculated as the distance in the frontal plane between the estimated foot centroids sampled at successive midstances. Step length was calculated as the fore-aft distance between foot centroids when the foot was flat on the floor. The velocity of the COM (vCOM) was calculated using a first-central difference algorithm, and used to quantify average forward step vCOM and peak lateral vCOM on a step-by-step basis. The medio-lateral vCOM was always positive towards the lead stepping limb. For the lateral step trials, these values were extracted from a window, defined from a given heelstrike to the contralateral heelstrike.

Ground reaction forces were collected from the force plate where stepping targets were placed (AMTI, Newton, MA, Fig. 1), and sampled at 1200 Hz. Inverse dynamics were computed from the synchronized motion capture and force plate data using a commercial software package (Orthotrak, Motion Analysis Corporation, Santa Rosa, CA). The internal frontal plane hip joint moment, which is bimodal in form, and primarily an abduction moment, was of particular interest. The initial abduction peak relates to arresting and redirecting the lateral velocity of the COM (Pandy et al., 2010), and thus, this value was used to characterize the peak hip joint abduction moment normalized by body mass. We also quantified continuous frontal plane muscular power of the hip with respect to the hip ab/adductor moment and the angular velocity of the limb ab/adduction angular motion. We were particularly interested in the peak negative hip power, which relates to energy absorption and occurred during the first half of stance phase.

For this investigation, we quantified dynamic stability as the relationship between the frontal plane position and velocity of the COM, with respect to the lateral edge of the base of support (Hof et al., 2005). The position and velocity of the COM within the frontal plane were used to define the extrapolated COM (xCOM: Eq. 1). The velocity of the COM was normalized by the eignenfrequency, or natural frequency, of a non-inverted pendulum with length 1.34 times the trochanteric height (ω_0) (Massen and Kodde, 1979)

$$\mathrm{xCOM}=\mathrm{COM}+\mathrm{vCOM}/\omega_0 \quad (1)$$

Dynamic stability is quantified using the margin of stability (MOS), which can quantify stability on a step-by-step basis. The MOS considers the distance between the xCOM and the lateral border of the BOS (Hof et al., 2005) (Eq. 2). Negative MOS value is indicative of the need for a compensatory reaction to resolve the unstable condition

$$\mathrm{MOS}=\mathrm{BOS}_{\mathrm{lat}}-\mathrm{xCOM}. \quad (2)$$

The lateral border of the BOS was calculated with respect to the positions of the heel and toe markers that were used to compute the angle of toe-in or toe-out for a given step, and anthropometric estimations of foot width (Rosenblatt and Grabiner, 2010). The MOS was quantified at heelstrike ($\mathrm{MOS}_{\mathrm{hs}}$).

For this experiment, we tested the hypothesis that following foot placement the stepping limb peak hip abduction moment of the older adults would be significantly smaller than younger adults, particularly at the longer step targets. The hypothesis was tested using a three-factor ANOVA, Step (COS vs. SS) × Target (long, medium, short) × Age (older vs. younger), with repeated measures on the Step and Target terms and a between factors term on Age. We tested the hypothesis that older adults would be less dynamically stable at heelstrike than younger adults, particularly at the longer step targets by utilizing a three-factor ANOVA (Step × Target × Age) with repeated measures on the Target and Step terms and a between factors term on Age. To test whether step widths of individuals stepping to targets was different between groups, a three factor ANOVA was performed.

As secondary analyses we also tested differences in the forward directed vCOM and peak lateral vCOM with two mixed three-factor ANOVA with repeated measures on the Target and Step terms. For instances in which significant interactions of interest were detected, follow-up tests were performed on the simple comparisons with Bonferroni corrections applied for the number of comparisons made. We also quantified the step angle (i.e., atan (step width/step length)), to descriptively compare the deviation of individuals from the direction of walking when performing the laterally-directed step. Finally, in the event of a significant difference in peak hip abduction moment, we compared peak negative hip power using preplanned pairwise comparisons of the effect of age on COS at the three different step distances and SS at the three different step distances using independent *t*-tests with a Bonferroni correction for number of comparisons made. Inclusion of this analysis was carried out to determine whether differences in peak hip moment generation resulted in age-related difference in peak hip absorption power. Significance was set at $p<0.05$ unless corrections were applied. Effect size was reported as Cohen's *d*. All statistics were performed with SPSS 17.0 (IBM Armonk, NY).

3. Results

3.1. Step width and walking speeds

While walking normally, no difference was observed in key frontal plane variables between older adults and younger adults (i.e., MOS, step width, and peak lateral velocity, Table 1). No significant age-related difference was detected in step width while performing laterally-directed steps ($F(2,70)=0.122$, $p=0.051$, Table 2). There was a 4% difference in the lateral step widths between groups which was slightly smaller than the 5% difference recorded between groups during normal walking (Table 1). The average step widths of the participants to the short, medium, and long step created a step width that was, on average, approximately 2, 3, and 4 times larger than their self-selected step width respectively. Small differences between older and young were observed in the step angle ranging from one to six degrees (Table 1), suggesting that comparisons of the dependent variables were warranted.

The forward directed vCOM of older adults was significantly slower than younger adults whether walking normally or performing laterally-directed steps. A significant Target × Age interaction was detected ($F(2,70)=4.216$, $p=0.019$, Table 2). Post-hoc tests showed that older adults performing laterally-directed steps to the long, medium, and short targets had a 25%, 20% and 20% slower forward directed vCOM than younger adults ($t(35)< -5.424$, $p<0.001$, for all comparisons).

3.2. Initial peak hip abduction moment of stepping limb

On average, the hip abduction moments of older adults were larger than younger adults across step types (Fig. 2). Within the model, the three way Step × Target × Age interaction was not significant ($F(2,70)=0.012$, $p=0.427$). The Target × Age interaction related to the hypothesis was also not significant ($F(2,70)= 2.538$, $p=0.086$). The Step × Age was also not significant ($F(1,35)=1.686$, $p=0.203$). A main effect of age was detected in the model ($F(1,35)=8.085$, $p=0.007$, Cohen's $d=0.95$, 0.846 N m/kg for older adults and 0.592 N m/kg for younger adults, Fig. 3). The computed internal hip abduction moments of older adults were, on average, 42% greater than younger adults

3.3. Effect of step type and target distance on dynamic stability

Older adults were more stable than younger adults while performing the targeted laterally-directed steps. Within the statistical model, the Step × Target × Age interaction term was not significant ($F(2,70)=0.497$, $p=0.610$). The Target × Age interaction related to the hypothesis was not significant ($F(2,70)=3.031$, $p=0.055$, Fig. 4). The Step × Age interaction was not significant ($F(1,35)=2.780$, $p=0.104$). A main effect of age was detected ($F(1,35)=16.099$, $p<0.001$, Cohen's $d=1.32$). Across all conditions older adults established a MOS_{hs} that was 48% larger than younger adults (9.5±2.3 cm vs. 6.4±2.3 cm).

3.4. Peak laterally-directed vCOM and peak hip power absorption

The peak lateral vCOM of older adults was slower for all targeted step widths, which resulted in similar peak negative joint power. No significant differences were detected in the Step × Target × Condition interaction of the measured peak lateral step velocity ($F(2,70)=0.777$, $p=0.464$). The Step × Target interaction ($F(2,70)=1.974$, $p=0.147$) and Step × Age interaction ($F(1,35)= 0.832$, $p=0.368$) were also not significant. A significant Target × Age interaction was detected ($F(2,70)=6.599$, $p=0.002$). *Post-hoc* tests on this ordinal interaction were performed with an adjusted p-Value of 0.016 for significance (i.e., 3 comparisons/0.05). All between group comparisons of target were significant (large steps $t(35)= -5.713$, medium steps $t(3)= -4.303$, and short steps $t(35)= -4.344$, $p<0.001$ for all comparisons). Stepping to targets resulted in no statistical differences in peak negative power occurred during the first half of stance (adjusted p-Value for significance=0.05/6compairson=0.008 Fig. 5, $t(1,35)$, $p>0.0017$).

4. Discussion

The purpose of the current investigation was to examine the age-related differences in frontal plane dynamic stability by examining the MOS and hip abductor moment generation of subjects performing a single COS and SS to targets that created three different step widths during forward locomotion. We hypothesized we would observe a significantly smaller peak hip abduction moment by older adults, compared to younger adults during the stance phase of the lateral step, particularly at the longer step targets. The peak hip abduction moments of older adults were, on average, 42% greater than younger adults Therefore, the hypothesis was not supported. We also hypothesized that older adults would be less dynamically stable at heelstrike while performing COS and SS than younger adults, particularly at the longer step targets for which the largest abduction moments would be expected. However, older adults were more dynamically stable at heelstrike than younger adults. Consequently, the hypothesis was not supported.

4.1. Frontal plane hip kinetics

The larger peak moments observed for older adults compared to younger adults in the current investigation may be a generalization of the reported neuromuscular strategy, that results in greater sagittal plane hip moment and power generation during normal walking

(DeVita and Hortobagyi, 2000; Franz and Kram, 2014; Silder et al., 2008). Conversely, the increased hip abductor moments by older adults may also represent a compensatory strategy related to the performance of this task. Hip abduction moment magnitudes scale linearly with speed (Rutherford and Hubley-Kozey, 2009), however younger adults walked approximately 28% faster across all conditions. Further, the larger peak lateral vCOM would theoretically require greater hip moments to arrest its lateral motion. Thus, the larger moments observed in this investigation by older adults may be counterintuitive. However, the decreased horizontal speed (both forward and lateral) and increased moment may be suggestive of a compensatory strategy to ensure dynamic stability by older adults. The similarities in power absorption at the hip were also of interest. It is has been suggested that older adults have a reduced capacity to absorb mechanical power within the sagittal plane compared to younger adults while recovering from a feet-in-place postural disturbance (Hall and Jensen, 2002). Negative work must be performed on the COM to arrest the lateral motion while performing lateral steps (Pandy et al., 2010). Thus, frontal plane hip power absorption could be an important variable related to maintenance of frontal plane stability. Currently, few investigations have reported age-related differences of frontal plane hip kinetics related to balance control (Mille et al., 2005).

4.2. Age-related difference in dynamic stability

Older adults established a stable MOS_{hs} (i.e., greater than 0) despite the increased lateral vCOM observed with the larger step widths. Performance of lateral steps required an increased lateral displacement and vCOM compared to normal walking. Stepping to long, medium, and short targets resulted in peak vCOM that was approximately 5.3, 3.9 and 2.6 times larger than during normal walking respectively. One potential explanation could relate to a difference between a stability and maneuverability tradeoff (Huang and Ahmed, 2011). A motor control strategy that favors stability could manifest in the lateral-step performance we observed by older adults, whereas, younger adults would likely favor maneuverability, suggested by the higher horizontal velocities and the similarity in walking speed between the overground and lateral step trials, ultimately resulting in decreased dynamic stability compared to older adults. We previously observed a stronger step-by-step relationship between trunk COM kinematics and step width of older adults compared to younger adults during treadmill walking (Hurt et al., 2010). The stronger relationship was suggested to relate to intentionally increased control over COM kinematics to avoid a misstep off the treadmill belt, a potentially destabilizing event that older adults would likely seek to avoid. Similarly, an inability to arrest lateral motion of the COM in the present study would result in a destabilizing event older adults would likely seek to avoid.

It has been reported that older adults are vulnerable to medial–lateral instability (Hilliard et al., 2008; Maki et al., 2000; McIlroy and Maki, 1996; Mille et al., 2005). A potential limitation of external postural disturbances is that subjects usually start from a quasi-static standing posture. The strength of the current investigation is that frontal plane dynamic stability was assessed with a dynamic challenging task As a result, we found that older adults generated a larger hip abduction moment, despite executing these laterally-directed steps more slowly (both fore-aft and mediolaterally) and were more dynamically stable at heelstrike than younger adults. Performance of laterally-directed steps allows for the manipulation of not only spatial, but also temporal aspects of the step as a way to scale the difficulty of the task.

4.3. Limitations

The trials of this study were performed in the same order for all subjects, potentially creating an ordering effect of our results. However, the data presented scales with the size of the step suggesting the presented order of the trials did not influence individuals' performance. Further, the inherent differences between SS and COS may preclude transfer. Because these steps were performed with the dominant limb, the direction the subject stepped was different between the COS and SS. Furthermore, the orientation of the lower limbs is quite different between a COS and a SS, creating a different step conditions. The sample of older adults reported a high level of self-reported physical functioning, i.e., the MOS 36 (Table 1), suggesting they were healthy and active. However, investigations that have suggested older adults may be more laterally unstable have utilized a similarly healthy cohort (Maki et al., 2000; Mille et al., 2005). It would be of interest to utilize this lateral step paradigm on older adults who have some clinical presentation related to decreased balance or stability to investigate generalizability of these results. Finally, the performance of the lateral step task was not constrained to ensure that these laterally-directed steps were performed with the exact same kinematic patterns. Thus it is possible that the age-related differences we report in our key dependent variables could have been influenced by the observed differences in task performance. However, despite a trend for increasing differences at the larger step angles, age-related differences in key dependent variables did not follow this trend thus we feel the age-related comparisons to be justified.

4.4. Conclusions

Age-related differences existed in the performance of targeted laterally-directed steps. The step widths of older and younger adults were the same, although younger adults exhibited a significantly greater peak lateral vCOM, likely related to a smaller MOS_{hs}. Surprisingly, larger peak hip abduction moments were observed for older adults. Differences in hip abduction moments may reflect greater muscular effort by older adults to reduce the likelihood of becoming unstable. The results of this investigation, in which subjects performed progressively larger lateral-directed steps provide evidence that older adults may not be more laterally unstable than younger adults. However, age-related differences in this study could reflect a compensatory strategy by older adults to ensure stability while performing this task.

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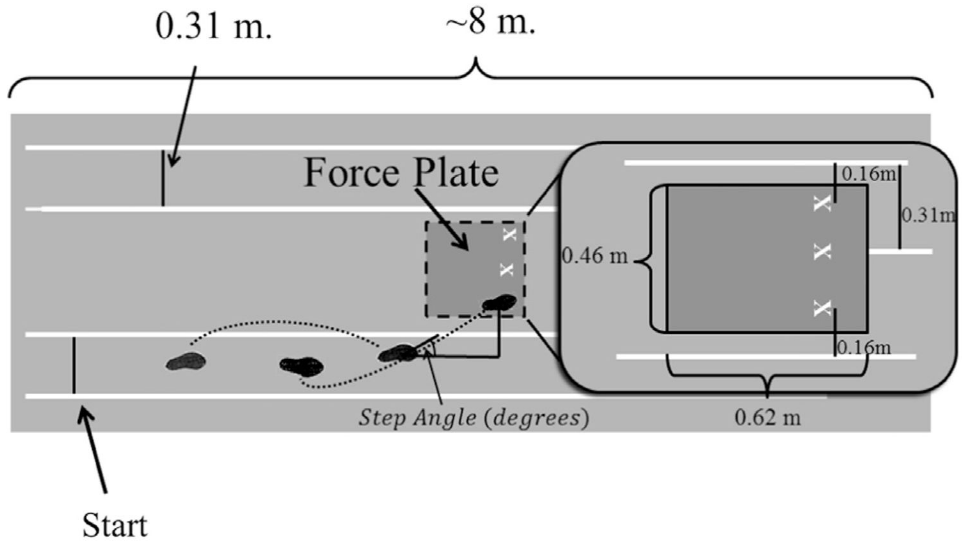

Fig. 1.

Schematic diagram of the experimental setup used for this protocol. All lateral steps were performed with the individual's dominant limb as the lead limb. For instance, for a right limb dominant individual performing a crossover step (see foot pattern above), the individual would start the trial in the lane to the right of the force plates and would take the step towards the subjects left. Conversely, the same individual would perform a sidestep by beginning the walking trial in the lane to the left of the force plates and execute the step to the subject's right. Also illustrated are the targets to which subjects stepped during the data collection (inset).

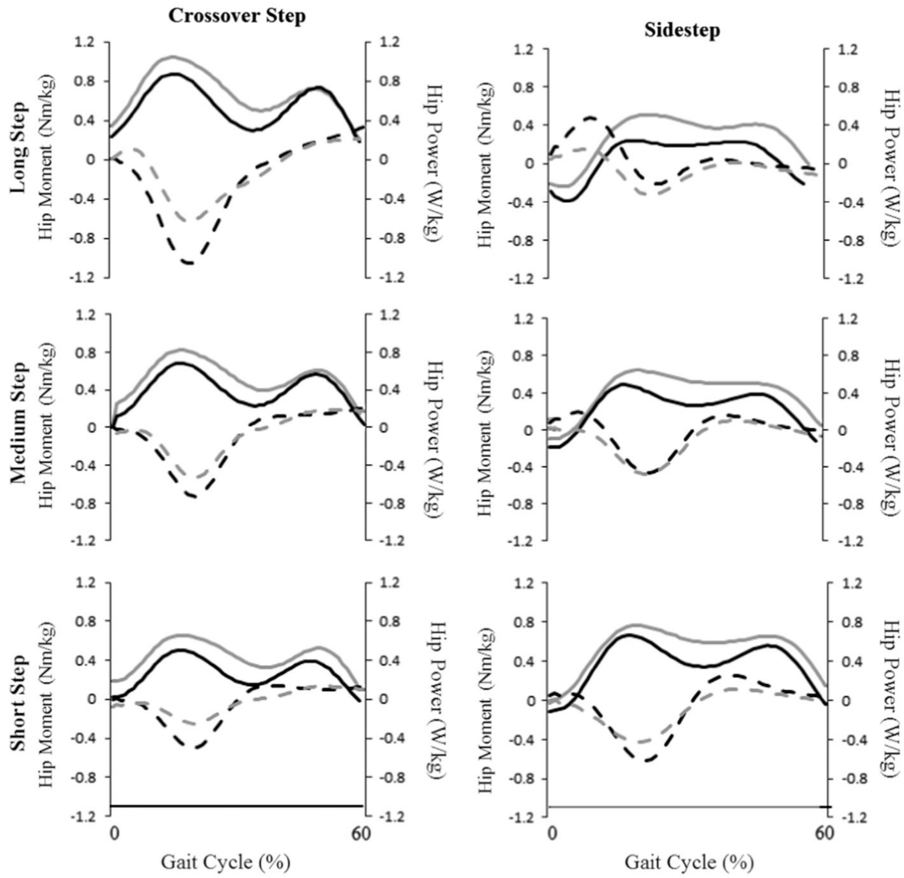

Fig. 2.

Ensemble moment and power plots of younger and older adults. Average frontal plane hip joint moment (solid line) and powers (dashed line) during the stance phase of the gait cycle for crossover steps (left column) and sidesteps (right column) for long lateral steps (top row), medium lateral step (middle row) and short lateral steps (bottom row). Mean ensemble curves of older adults (gray) and younger adults (black) are illustrated. Positive values for frontal plane hip moment relate to hip abduction while negative power relates to power absorption.

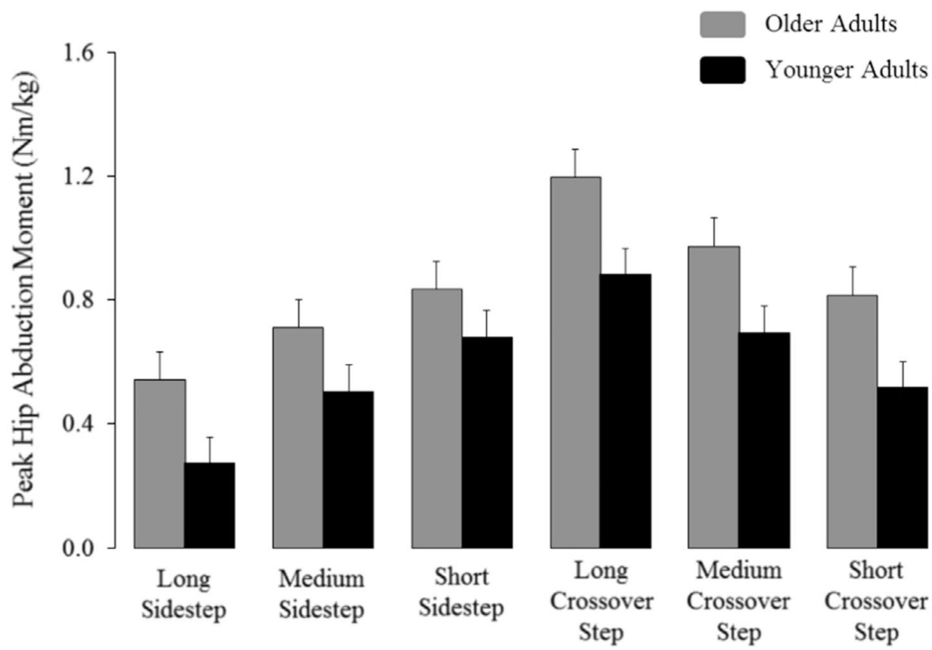

Fig. 3.

Peak hip abduction moments. The average peak hip abduction moment (+standard error) of older (gray) and younger (black) adults for long, medium, and short lateral steps. On average the peak frontal plane hip abductor moment was 42% greater than younger adults (p=0.007).

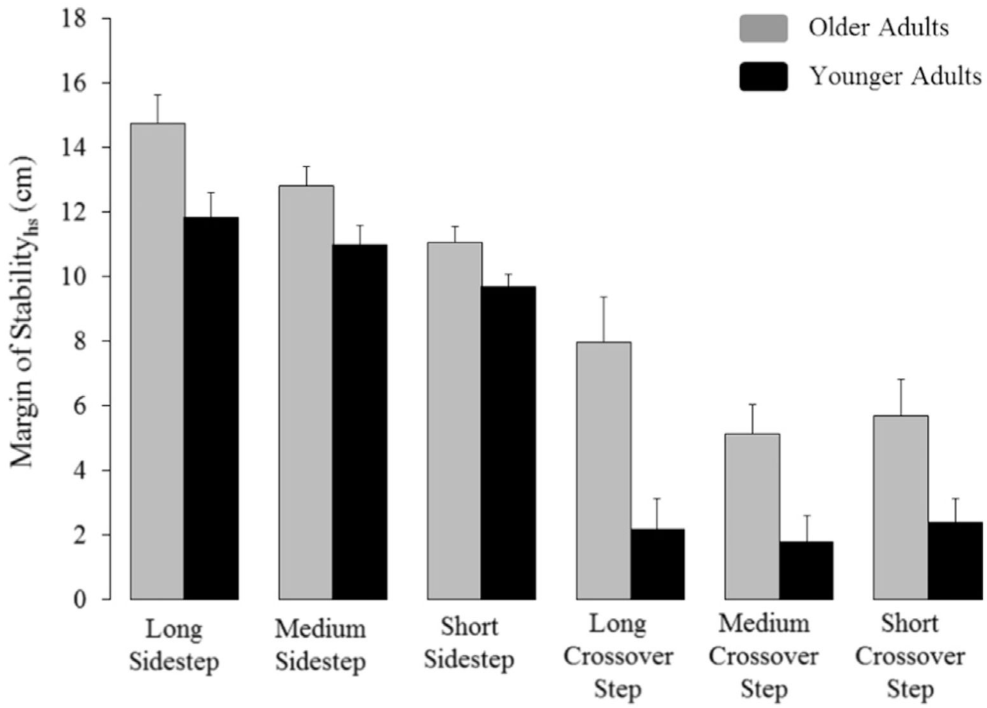

Fig. 4.

Margin of stability at heel strike while stepping to targets. The average margin of stability (+standard error) of older (gray) and younger (black) adults for long, medium, and short lateral steps is shown. Older adults were more stable than younger adults across all targets *p*<0.001. On average, the lateral steps of older adults conferred a greater level of stability.

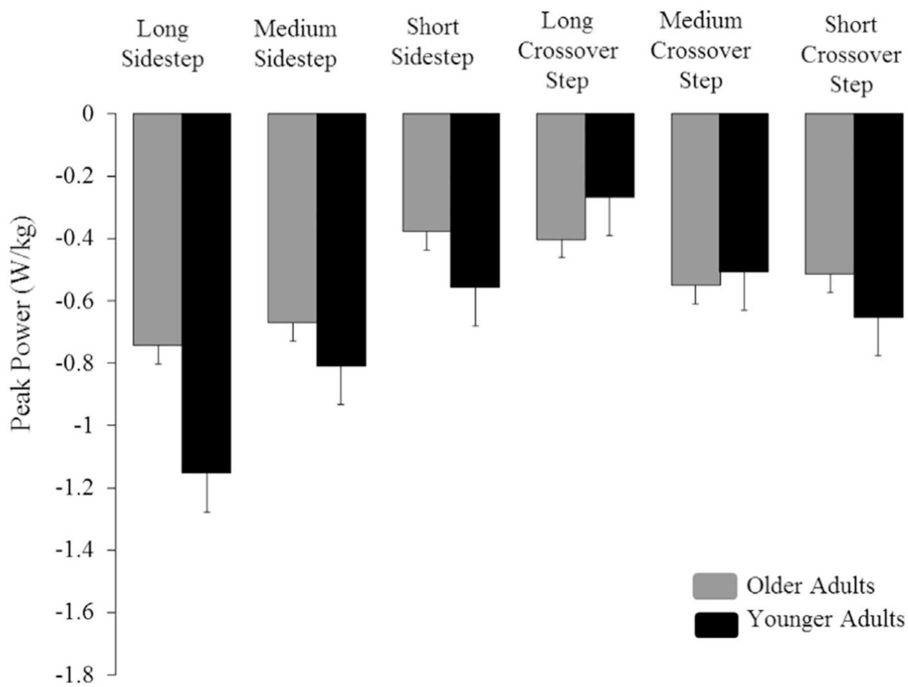

Fig. 5.

Peak power absorption while stepping to targets. The average peak negative power (−standard error) of older (gray) and younger (black) adults for long, medium, and short lateral steps is shown. The only group related difference between each steps was detected between the long sidesteps (*p*=0.017); otherwise, all other comparisons did not reach significance (*p*>0.089).

Table 1

Mean and standard error of normal walking along with a measure of physical functioning. Listed in the table is the statistical comparison of older and younger adults walking normally. It should be noted that no significant differences exist in frontal plane kinematic data. Also listed is the average composite score for the MOS-36 physical functioning scale for older adults.

	Condition	Older adults	Younger adults	*p*-Value
Step width (cm)	Normal	13.3±1.0	12.7±0.5	0.713
Step length (cm)	Normal	71.2±2.0	76.3±1.2	<0.001
Forward velocity (cm/s)	Normal	13.3±0.4	14.7±0.3	0.003
Peak lateral velocity (cm/s)	Normal	14.5±0.7	13.2±0.4	0.120
MOS_{avg} (cm)	Normal	8.0±0.2	8.1±0.2	0.327
MOS-36 short form	–	86.4±2.0	–	–

Table 2

Step kinematics of individuals performing lateral steps. Mean±standard error of step width, step length, step angle (atan (step width/step length)) and the peak lateral velocity of older and younger performing long medium and short sidesteps and crossover steps are shown.

Group	Distance	Step type	Step width (cm)	Step length (cm)	Step angle (deg)	Peak lateral velocity (cm/s)	Forward walking speed (cm/s)
Old	Long	Sidestep	57.4±1.2	55.5±2.5	46.3±1.4	77.3±1.2	105.5±39.6
Young			59.5±1.1	69.7±1.4	40.4±0.9	84.2±0.8	141.3±42.1
Old	Long	Crossover	53.8±1.0	63.2±1.7	40.6±0.8	77.2±1.0	104.4±33.3
Young			55.5±0.9	73.3±1.4	37.2±1.0	84.0±1.2	139.1±39.3
Old	Medium	Sidestep	43.1±0.8	62.6±2.4	35±1.2	57.2±1.0	116.2±36.6
Young			44.7±0.8	71.8±1.2	31.8±0.9	61.2±0.9	144.4±40.4
Old	Medium	Crossover	38.8±0.9	68.3±2.3	29.8±0.9	56.8±1.0	113.7±38.9
Young			40.4±0.9	75.3±1.3	28.3±1.0	63±1.0	143.2±38.2
Old	Short	Sidestep	29.6±0.8	61.6±2.4	26.1±1.0	39.3±0.8	117.9±40.3
Young			31.2±0.8	72.2±1.3	23.6±0.8	42.1±0.9	147.8±38.6
Old	Short	Crossover	23.9±0.8	66.5±2.1	20.0±0.8	37.1±0.8	117.5±35.8
Young			25.0±0.8	75.1±1.0	19.0±0.7	41.7±0.8	146.7±34.9