The manuscript below is the post-refereeing version which has been accepted for publication in Gait and Posture (http://www.journals.elsevier.com/gait-and-posture/)

Title

Carrying shopping bags does not alter static postural stability and gait parameters in healthy older females

Authors

Theodoros M. Bampouras, Susan Dewhurst

Affiliations

Active Ageing Research Group, Faculty of Health and Science, University of Cumbria

Bowerham Road, Lancaster, LA1 3JD, United Kingdom.

Email address: theodoros.bampouras@cumbria.ac.uk, susan.dewhurst@cumbria.ac.uk

Corresponding Author

Theodoros M. Bampouras, Active Ageing Research Group, Faculty of Health and Science, University of Cumbria, Bowerham Road, Lancaster. LA1 3JD.

Email: theodoros.bampouras@cumbria.ac.uk, Tel: +44 (0)1524 590837

Acknowledgements: The authors are grateful to the Research and Scholarly Development Fund, University of Cumbria for financial support to this project. The funding body had no involvement with the research process. Both authors contributed equally to the study.

Abstract

Food shopping is an important aspect of maintaining independence and social interaction in older age. Carriage of shopping bags alters the body's weight distribution which, depending on load distribution, could potentially increase instability during standing and walking. The study examined the effect of carrying UK style shopping bags on static postural stability and gait in healthy older and young females. Nine older (71.0±6.0 years) and 10 young (26.7±5.2 years) females were assessed in five conditions carrying no bags, one 1.5kg bag in each hand, one 3kg bag in each hand, one 1.5kg bag in preferred hand, one 3kg bag in preferred hand. Antero-posterior and medio-lateral displacement, and 95% ellipse area from a 30s quiet standing were used for postural stability assessment. Stride length and its coefficient of variation, total double support time, step asymmetry and gait stability ratio were calculated from one minute treadmill walking at self-selected speed for gait assessment. Carrying shopping bags did not negatively affect postural stability or gait variables, in either group. Further, in older individuals, a decrease in sway velocity was found when holding bags during the postural stability assessment ($p<0.05$), suggesting that carriage of bags, irrespective of the load distribution, may have a stabilising effect during quiet standing.. These results should help to alleviate concerns regarding safety of carrying shopping bags and help encourage shopping, both as a social and as a physical activity.

Keywords

Ageing, elderly, functional tasks, walking, balance

Introduction

Being able to shop for food in later life is an important aspect of being independent and staying well. With more time at the older adults' disposal, shopping becomes a social activity as well as a daily necessity, with older individuals reporting spending extra time to meet friends, socialise and maintain their health [1].

Carrying the shopping bags home, however, may pose an additional challenge to the individual's postural stability during standing and walking, as the carriage of UK style shopping bags (Fig. 1) will impact on the centre of mass (CoM) location and behaviour during standing and locomotion. Initially, carrying the shopping bag would lower the centre of gravity, creating a more balanced stance. However, if this stance was disturbed, a torsion effect would be created, making recovery from the perturbation difficult. Similarly, when walking, the trunk sway experienced during normal gait may be exaggerated due to the (bilateral or unilateral) load carriage, further increasing the instability of the walk [2]. Notwithstanding the commonality of carrying shopping bags in everyday life, and its potential impact on stability and consequently falls in elderly, this area has not been previously researched. Previous studies utilised loads placed on the back (e.g. [3]) or the waist (e.g. [4]), positions which will affect the CoM differently to how the shopping bags would. Indeed, carrying a one-sided bag, such as a briefcase, a single-strap bag or purse, has been found to decrease lateral static postural stability in young individuals [5]. Such an effect, if also true for older individuals, could increase fall risk, as lateral instability impacts on the gait parameters associated with fall risk [6]. Further, carrying a shopping bag unilaterally, is very likely to impact on lateral instability [7] and more so during the single leg stance phase, as the individual's base of support is reduced while the centre of mass is 'shifted' laterally, again impacting on postural stability and gait and potentially, falling.

A consequence of falling, even if no injury occurs, is a fear of falling in the future. This fear of falling may limit the physical activities performed, and this reduction may in turn lead to reduced mobility and physical fitness which further increases risk of falling [8]. The purpose of the present study, therefore, was to examine the hypothesis that carrying shopping bags can decrease static postural stability and have negative effects on gait parameters in older individuals.

Methodology

Subjects

Following ethical approval from the Institutional Ethics Committee, nine older (mean±SD: aged 71.0±6.0 years, age range: 68–75 years, body mass 66.3±10.1 kg, stature 1.65±0.06 m) and 10 young (mean±SD: aged 26.7±5.2 years, age range 22–31 years, body mass 70.2±15.1 kg, stature 1.69±0.05 m) healthy females agreed to participate in the study and provided written, informed consent. Participants were free of any injury for at least six months prior to testing and able to conduct daily activities independently and without the use of any aid.

Procedures

Participants were familiarised with the experimental set-up and testing took place on a single occasion. Height and weight were measured and both hands' handgrip strength was assessed with a handgrip dynamometer (Takei Scientific Inst. Co. Ltd, Niigata, Japan). Following this, participants were assessed (in a randomised order) on static postural stability and gait, performing five conditions for each assessment; no bags, one 1.5kg bag in each hand, one 3kg bag in each hand, one 1.5kg bag in preferred hand only, one 3kg bag in preferred hand only. The loads were chosen to represent the mass of typical food older individuals are likely to purchase, e.g. half a loaf of bread (400/800 gr), one can of soup (~300 gr), 1L of milk (~1 kg) etc, and their order was randomised.

Static postural stability assessment

Static postural stability was assessed with the participants standing quietly on a force platform (AccuPower, Advanced Mechanical Technology Inc., Watertown, Massachusetts) for 35 seconds, with the first five seconds discarded; thus, data were averaged over 30 seconds. Subjects were to stand in a natural stance, wearing their spectacles if required, focusing on a visual target placed approximately three meters in front of them at eye level and remain as motionless as possible. Data were sampled at 100 Hz (NetForce, Advanced Mechanical Technology, Inc., Watertown, Massachusetts) and antero-posterior and medio-lateral displacements, sway velocity and sway area (95% ellipse area), were calculated (BioAnalysis, Advanced Mechanical Technology Inc., AMTI, Watertown, Massachusetts). Sway velocity indicates the speed at which CoP adjustments are made. Sway area (95% ellipse area) indicates the amount of CoP movement and is a method used to estimate the confidence area of the CoP path where approximately 95% of the points on the COP path are enclosed in [9,10].

Gait assessment

Older subjects were allowed to walk for at least 20 minutes on the treadmill (Woodway PRO-27, Woodway, Waukesha, Wisconsin, USA) to establish their comfortable walking speed [11], which was then used for all trials. To assess gait, subjects walked on the treadmill for two minutes, with the last minute recorded for analysis. Stride length (and coefficient of variation), total double support (in seconds and percentage of the overall stride duration) and step asymmetry (deviation from equal duration steps between left and right limb) were measured using the Optojump Optical Measurement System (Microgate, Italy). Gait stability ratio (GSR, calculated as the ratio of cadence to velocity) was also recorded for each variable [12].

Heart rate was measured from the treadmill's sensors at the end of each condition, immediately after the subjects have stopped, and recorded. Each value was then converted to percentage of the age-predicted maximum heart rate (calculated as 208-(0.7 x age)) [13].

Data Analysis

Normality of distribution was checked using the Shapiro-Wilk test and confirmed for all variables. A dependent t-test examined for handgrip strength differences between dominant and non-dominant hand, while an independent t-test was used to compare handgrip strength between the older and young group. Differences between groups and within loads in postural stability, gait and heart rate variables were examined with a 2 (group) x 5 (load) ANOVA. Only comparisons from significant main effects and interactions were further analysed and subsequently reported. Those were further examined by Mann-Whitney U test for differences between groups and repeated measures ANOVA, with dependent t-tests, if required, for differences between loads. Holm-Bonferroni correction was applied for multiple comparisons. Effect sizes (ES) were calculated for significant comparisons, with ES of 0.2, 0.5 and 0.8 indicating small, medium and large effects, respectively. An alpha level of 0.05 was used for all statistical comparisons. Data are given as mean±standard deviation (SD).

Results

The heaviest load (3kg in each hand, 6kg in total) was 9.2±1.2% and 8.9±1.8% of body mass for the older and young subjects respectively, which was not significantly different ($p=0.632$).

Handgrip

No differences were found between the dominant and non-dominant hands of either group, therefore the average of the two hands handgrip strength was used for the comparison between groups. Handgrip strength was 27% lower in the older compared to young subjects (21.0±6.5 kg and 28.8±4.5 kg respectively; $p=0.008$, ES=1.35), with both groups' scores falling between the 50th and 25th percentile for their respective age norms [14]. The load (3kg) as a percentage of handgrip strength was significantly greater in the older compared to the young (15.6±5.1% and 10.7±1.7%, respectively; p=0.002, ES=1.26).

Static postural stability assessment

There was a significant difference between age groups in the medio-lateral axis displacement when no load was carried (p=0.001, ES=1.0), with the young group showing a smaller displacement. This between group difference was removed when the participants were carrying bags, irrespective of the load and distribution. There were no significant differences between the groups for any of the trials for the antero-posterior displacement, sway velocity or sway area.

The carriage of bags affected the sway velocity in the older individuals, with significantly higher sway velocity found when no load was carried compared to carrying light load both hands (p=0.002, ES=0.32), heavy load both hands (p=0.012, ES=0.91), light load one hand (p=0.014, ES=0.54) and heavy load one hand (p=0.014, ES=0.51) while light load both hands was significantly higher than heavy load both hands (p=0.035, ES=0.56). In the younger subjects, the heavy load both hands resulted in significantly lower sway velocity compared to no load (p=0.041, ES=0.5), light load one hand (p=0.002, ES=0.46), and light load both hands (p=0.007, ES=0.31) (Table 1). Carriage of the bags did not affect the antero-posterior or medio-lateral displacement or sway area, in either the young or older groups (Table 1).

TABLE 1 ABOUT HERE

Gait assessment

Self-selected walking velocity was predictably significantly higher in the young compared to older individuals (1.13±0.08 and 0.81±0.15 $m \cdot s^{-1}$ respectively; p=0.001, ES=2.6). Similarly, stride length was also significantly higher for young compared to older for all load conditions (no load p=0.005, ES=1.5; light load both hands p=0.004, ES=1.6; heavy load both hands p=0.001, ES=1.97, light one hand p=0.001, ES=1.99; heavy load one hand p=0.002, ES=1.74). GSR was also significantly higher for older compared to younger for all conditions (no load p=0.01, ES=1.44; light load both hands p=0.004, ES=1.62; heavy load both hands *p*=0.001, ES=2.21, light load one hand p=0.001, ES=2.17; heavy load one hand p=0.002, ES=1.85). Finally, double support time was greater for older adults when no load was carried (p=0.01, ES=0.84). No other comparisons were significantly different between groups. With regards to carriage of the bags, the additional load did not affect any of the gait variables (Table 2).

TABLE 2 ABOUT HERE

Heart rate was not significantly different between groups (p>0.05) for any load. Significant differences were found for both groups with a higher heart rate for the light load both hands (older: p=0.015, ES=0.53; young: p=0.015, ES=0.45) and heavy load both hands (older: p=0.004, ES=0.70; young: p=0.005, ES=0.60) when compared to no load, and heavy load both hands when compared to heavy load one hand (older: p=0.001, ES=0.36; young: p=0.009, ES=0.30). No other differences were found for comparisons between loads for each age group (Table 3).

TABLE 3 ABOUT HERE

Discussion

The main finding of the present study was that carrying shopping bags is not detrimental to static postural stability or gait in young and older females, but instead may help to stabilise posture during quiet standing as seen from a reduced sway velocity. These results could be used to reduce fear of falling and subsequently encourage essential items shopping, reducing social isolation as well as maintaining independence and increasing physical activity in older individuals [15].

Static balance

Comparison between young and older subjects showed higher displacement in the medio-lateral axis for the no load only. As medio-lateral displacement has been suggested as one of the main predictors of falls in older individuals [16], this finding, in line with relevant literature (e.g. [17]), suggests that older individuals are in increased fall risk when carrying no load. Interestingly, however, this difference disappeared in the load carrying conditions. The results from the present study suggest that load carrying may have provided some stabilisation effect as almost all load conditions demonstrated a lower sway velocity compared to not carrying a load in the older individuals. As sway velocity is related to maintaining postural stability during quiet standing [10], a lower sway velocity indicates lower regulatory activity needed to maintain postural stability [18]. This finding relates well to recent research in healthy individuals showing that the haptic input from the hands can improve postural stability [19,20]. Holding a stick parallel to the ground with varying force levels, for example, has been shown to improve postural control in both static and dynamic conditions as seen by a decrease in sway velocity [19,21]. Carrying of shopping bags therefore may not only modify the mechanical distribution of body mass but may also modify the neural control of postural stability with the sensory input of the bags aiding balancing during quiet standing.

It was expected that the uneven distribution of mass with unilateral loading would impact on the control of posture in the medio-lateral plane [22], increasing the displacement in that direction. The medio-lateral displacement, however, was not increased with unilateral loading in either group. This disturbance of medio-lateral postural control has been reported previously when carrying a briefcase; young subjects showed a significantly increased displacement during quiet standing when carrying a briefcase of 20% body mass [5] but interestingly this increased displacement was not seen when the briefcase was 10% of body mass. The discrepancy in the results could be attributed to two possible reasons, load magnitude and postural adjustment. In the present study, the maximum load on one hand was lower than the load used in Zultowski and Aruin's [5] study (~4.5% v 20% of body mass, respectively). It is likely that the lighter load was not sufficient to cause any impact on displacement. Alternatively, the subjects could have adjusted their posture by a slight lean to the opposite side, 'correcting' for the shift caused by the unilateral load. This movement would have resulted in the centre of mass returning closer to the midline of the body, and thus maintaining a 'neutral' position. In the absence of kinematic data, the presence of such adaptation mechanism is purely speculatory and cannot be used to establish the reason behind this finding.

Gait assessment

A second positive outcome from the present study is that carrying the shopping bags did not affect the gait parameters in older or young participants, as no difference in any of the gait parameters was revealed. This maintenance of gait was despite an increased physiological demand when carrying both light and heavy bags bilaterally as seen by an increased heart rate in both groups. It was initially hypothesised that the increased distribution of load in the medio-lateral plane would create a greater acceleration due to the greater mass, or even a torsion effect, when balance was disturbed such as is the case when walking. In turn, this would challenge the muscle torque generating capacity around the ankles, hips or other joints of the older individual, adding a further complexity in maintaining the centre of gravity over the base of support. This muscle force generating capacity of older individuals is less than that of a younger individual and is partially responsible for the greater instability, increased fall risk and decreased recovery success from falls in the older population (for review please see [23]). The addition of the bags used in the present study, did not however affect dynamic stability, suggesting that the increased acceleration and torsion, if any, was mitigated by an adequate motor response.

An additional consideration was the carriage of bags unilaterally; lateral stability is an issue to older individuals not only in static situations, as discussed above, but also in locomotion. During walking, the centre of pressure (COP) of older individuals has been shown to have tendency to fall more towards the unsupported side of the gait cycle [24]. With the carriage of bags on one side only, it was hypothesised that this may cause a further shift toward the unsupported side when the side the bags are being carried on coincides with the unsupported phase of the gait cycle, while, in contrast, reduce the sway to the unsupported side when the gait cycle was in the stage where the supported leg coincided with the side the bags were being carried on. While COP was not measured during the gait cycle, any alteration in the COP displacement would have been reflected in increased variability in the gait pattern [25,26] which was not seen from the step asymmetry, the coefficient of variation of the stride length or GSR.

The results of the present study conformed to the expected findings that differences in gait parameters exist between older and young subjects with older individuals having a slower gait velocity and shorter stride length as well documented in previous studies (e.g. [27,28]). GSR is an indication of the individual’s ability to deal with the dynamic nature of walking [12]. Increased GSR points to increased number of steps (normalised for velocity) and thus, more time spent in contact with the ground, as when one needs increased stability. Our results show an increased GSR for the older compared to the young, which support the concept of the olders' need for greater stability during walking, possibly to achieve better control of the upper body and decrease the ground reaction forces of a larger stride [29].

Prolonged shopping bags carriage could eventually lead to localised fatigue in the forearms, hands, shoulders and trunk. It is unlikely, however, that this occurred in the present study, as the maximum amount of time the subjects were carrying the loads for was for two minutes per gait trial. Fatiguing the upper body in young subjects has been found to affect dynamic balance [30]. Assuming application of these results to older population, prolonged duration of shopping carriage (or increase in load) could result in different findings to the present study. In addition, the use of treadmill poses its own limitations to the study. Treadmill walking can differ to overground walking due to the walk being level and at constant speed. These aspects somewhat restrict the 'ecological validity' of the findings, as typical walking routes would include obstacles, curbs, bends and change of gradient. In addition, it is also likely walking speed would change in response to these factors, as well as potentially to load carriage, altering stability.

Conclusion

The findings of the present study that carrying shopping bags does not negatively affect postural stability or gait should alleviate concerns about instability during a shopping excursion. By reducing this fear of falling, individuals will not limit this activity which provides both physical and social benefits. A question for future studies is how carrying the bags would affect the ability to recover from a trip from an external challenge such as an unseen obstacle or change in under foot conditions, in which the individuals are forced to take actions to prevent falling.

Conflict of interest statement

None

References

[1] AgeUK. Food shopping in later life – barriers and service solutions. London, UK: AgeUK.

[2] Allum JH, Adkin AL, Carpenter MG, Held-Ziolkowska M, Honegger F, Pierchala K. Trunk sway measures of postural stability during clinical balance tests: effects of a unilateral vestibular deficit. Gait Posture 2001;14(3):227-37.

[3] Yen SC, Ling W, Magill R, McDonough A, Gutierrez GM. Temporal relationship between trunk and thigh contributes to balance control in load carriage walking. Gait Posture 2011;34(3):402-8.

[4] Arellano CJ, Layne CS, O'Connor DP, Scott-Pandorf M, Kurz MJ. Does load carrying influence sagittal plane locomotive stability? Med Sci Sports Exerc 2009;41(3):620-7.

[5] Zultowski I, Aruin A. Carrying loads and postural sway in standing: the effect of load placement and magnitude. Work 2008;304:359-68.

[6] Dean JC, Alexander NB, Kuo AD. The effect of lateral stabilization on walking in young and old adults. IEEE Trans Biomed Eng 2007;5411:1919-26.

[7] Zhang XA, Ye M, Wang CT. Effect of unilateral load carriage on postures and gait symmetry in ground reaction force during walking. Comput Methods Biomech Biomed Engin 2010;13(3):339-44.

[8] Vellas BJ, Wayne SJ, Romero LJ, Baumgartner RN, Garry PJ. Fear of falling and restriction of mobility in elderly fallers. Age Ageing 1997;263:189-93.

[9] Dewhurst S, Riches PE, De Vito G. Moderate alterations in lower limbs muscle temperature do not affect postural stability during quiet standing in both young and older women. J Electromyogr Kinesiol 2007;173:292-8.

[10] Prieto TE, Myklebust JB, Hoffmann RG, Lovett EG, Myklebust BM. Measures of postural steadiness: differences between healthy young and elderly adults. IEEE Trans Biomed Eng 1996;439:956-66.
[11] Schellenbach M, Lovden M, Verrel J, Kruger A, Lindenberger U. Adult age differences in familiarization to treadmill walking within virtual environments. Gait Posture 2010;313:295-9.
[12] Cromwell RL, Newton RA. Relationship between balance and gait stability in healthy older adults. J Aging Phys Act 2004;121:90-100.
[13] Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. J Am Coll Cardiol 2001;371:153-6.
[14] Dodds RM, Syddall HE, Cooper R, Benzeval M, Deary IJ, Dennison EM, Der G, Gale CR, Inskip HM, Jagger C, Kirkwood TB, Lawlor DA, Robinson SM, Starr JM, Steptoe A, Tilling K, Kuh D, Cooper C, Sayer AA. Grip strength across the life course: normative data from twelve British studies. PLoS One 2014;912:e113637.
[15] Hornyak V, Brach JS, Wert DM, Hile E, Studenski S, Vanswearingen JM. What is the relation between fear of falling and physical activity in older adults? Arch Phys Med Rehabil 2013;9412:2529-34.
[16] Mille ML, Johnson ME, Martinez KM, Rogers MW. Age-dependent differences in lateral balance recovery through protective stepping. Clin Biomech (Bristol, Avon) 2005;206:607-16.
[17] Raymakers JA, Samson MM, Verhaar HJ. The assessment of body sway and the choice of the stability parameter(s). Gait Posture 2005;211:48-58.
[18] Dewhurst S, Peacock L, Bampouras TM. Postural stability of older female Scottish country dancers in comparison with physically active controls. J Aging Phys Act 2015;231:128-32.

[19] Ustinova KI, Langenderfer JE. Postural stabilization by gripping a stick with different force levels. Gait Posture 2013;381:97-103.
[20] Hausbeck CJ, Strong MJ, Tamkei LS, Leonard WA, Ustinova KI. The effect of additional hand contact on postural stability perturbed by a moving environment. Gait Posture 2009;293:509-13.
[21] VanderHill MS, Wolf EE, Langenderfer JE, Ustinova KI. The effect of actual and imaginary handgrip on postural stability during different balance conditions. Gait Posture 2014;404:652-7.
[22] Winter DA, Prince F, Stergiou P, Powell C. Medial-lateral and anterior-posterior motor responses associated with COP changes in quiet standing. Neurosci Res Commun 1993;123:141-8.
[23] Pijnappels M, Reeves ND, Maganaris CN, van Dieen JH. Tripping without falling; lower limb strength, a limitation for balance recovery and a target for training in the elderly. J Electromyogr Kinesiol 2008;182:188-96.
[24] McIlroy WE, Maki BE. Age-related changes in compensatory stepping in response to unpredictable perturbations. J Gerontol A Biol Sci Med Sci 1996;516:M289-96.
[25] Bizovska L, Svoboda Z, Kutilek P, Janura M, Gaba A, Kovacikova Z. Variability of centre of pressure movement during gait in young and middle-aged women. Gait Posture 2014;40(3):399-402.
[26] Hollman JH, McDade EM, Petersen RC. Normative spatiotemporal gait parameters in older adults. Gait Posture 2011;34(1):111-8.
[27] Begg RK, Sparrow WA. Gait characteristics of young and older individuals negotiating a raised surface: implications for the prevention of falls. J Gerontol A Biol Sci Med Sci 2000;553:M147-54.

[28] Laufer Y. Effect of age on characteristics of forward and backward gait at preferred and accelerated walking speed. J Gerontol A Biol Sci Med Sci 2005;605:627-32.
[29] Woollacott MH, Tang PF. Balance control during walking in the older adult: research and its implications. Phys Ther 1997;776:646-60.
[30] Douris PC, Handrakis JP, Gendy J, Salama M, Kwon D, Brooks R, Salama N, Southard V. Fatiguing upper body aerobic exercise impairs balance. J Strength Cond Res 2011;2512:3299-305.

FIGURE LEGENDS

Fig. 1. Example of a UK style shopping bag, held unilaterally.

Tables

Table 1: Descriptive statistics for all postural stability variables for both groups. Data is displayed as mean ± SD.

		No	L-2	H-2	L-1	H-1
95% Ellipse area (cm^2)	Old	3.4±1.7	4.3±2.9	2.7±1.4	2.6±1.1	3.0±1.8
	Young	2.2±0.6	2.1±0.9	1.9±0.6	2.1±0.5	1.9±0.6
Sway velocity ($cm \cdot s^{-1}$)	Old	17.4±3.1	16.4±3.0 $^{No, H-2}$	15.0±2.1 ^{No}	16.0±2.2 ^{No}	16.3±3.0 ^{No}
	Young	15.3±2.6 $^{H-2}$	15.0±2.8 $^{H-2}$	14.0±2.4	15.3±3.0 $^{H-2}$	15.0±3.3
A-P (cm)	Old	0.44±0.14	0.44±0.14	0.39±0.12	0.42±0.13	0.35±0.07
	Young	0.44±0.15	0.37±0.08	0.41±0.12	0.42±0.11	0.36±0.07
M-L (cm)	Old	0.26±0.08	0.31±0.13	0.25±0.11	0.24±0.08	0.24±0.09
	Young	0.17±0.02 *	0.19±0.02	0.16±0.03	0.18±0.04	0.18±0.04

No: no load; L-2: light load both hands; H-2: heavy load both hands; L-1: light load single hand; H-1: heavy load single hand; A-P: antero-posterior axis; M-L: medio-lateral axis. * Significantly different from older ($p<0.05$); ^{No} significantly different from no load; $^{H-2}$ significantly different from heavy load both hands.

Table 2. Descriptive statistics for all gait variables for both groups. Data is displayed as mean ± SD.

		No	L-2	H-2	L-1	H-1
Stride length (m)	Old	1.02±0.16	1.01±0.15	0.98±0.14	1.00±0.13	1.00±0.16
	Young	1.23±0.09*	1.22±0.10*	1.23±0.10*	1.23±0.10*	1.23±0.09*
Stride Length CoV (%)	Old	3.1±1.3	3.7±1.9	3.1±1.4	2.9±1.0	5.3±6.1
	Young	2.1±0.8	2.0±0.8	2.2±0.9	2.0±0.8	2.0±0.8
Double support (s)	Old	0.42±0.09	0.42±0.10	0.42±0.11	0.41±0.10	0.36±0.16
	Young	0.34±0.09*	0.34±0.10	0.34±0.09	0.34±0.09	0.34±0.09
Double support (%)	Old	34.6±5.3	34.7±5.1	35.3±5.3	34.3±4.7	30.4±11.5
	Young	30.5±5.1	30.6±5.4	30.8±5.2	30.7±5.0	30.4±5.1
Step asymmetry (%)	Old	1.11±1.04	0.84±0.51	0.85±0.54	1.23±0.98	1.19±1.06
	Young	0.73±0.35	0.72±0.47	0.99±0.75	1.14±0.61	1.02±0.87
GSR (steps·m^{-1})	Old	0.95±0.12	0.96±0.10	1.0±0.09	0.98±0.08	0.97±0.10
	Young	0.82±0.06*	0.82±0.07*	0.82±0.06*	0.82±0.06*	0.82±0.06*

No: no load; L-2: light load both hands; H-2: heavy load both hands; L-1: light load single hand; H-1: heavy load single hand; CoV: coefficient of variation; GSR: gait stability ratio. * Significantly different from older ($p<0.05$).

Table 3: Descriptive statistics for heart rate for both groups. Data is displayed as mean ± SD.

		No	L-2	H-2	L-1	H-1
Heart rate	Old	60.7±11.2	66.4±10.4 [No]	68.6±11.3 [No]	65.2±10.2	64.3±12.3 [H-2]
(%EstHEmax)	Young	60.0±10.6	64.7±10.4 [No]	66.6±11.5 [No]	64.0±9.8	63.1±11.6 [H-2]

No: no load; L-2: light load both hands; H-2: heavy load both hands; L-1: light load single hand; H-1: heavy load single hand; [No] significantly different from no load, [H-2] significantly different from heavy load both hands.