Modulation of the Hoffmann reflex in soleus and medial gastrocnemius during stair ascent and descent in young and older adults

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ABSTRACT

Background: The Hoffmann (H) reflex can provide relevant information on spinal control of leg muscles during locomotor tasks in young and older adults.

Research question: Is the H reflex in the leg muscles differently modulated during stair gait in young and older adults?

Method: The H reflex in soleus (SOL) and medial gastrocnemius (MG) (normalized to the maximal M-wave amplitude obtained during upright standing; M_{max}) was recorded in 19 young and 18 older adults during upright standing, and stair ascent and descent of a 3-step staircase.

Results: H-reflex amplitude during upright standing was greater in young than older adults for SOL (48% vs. 26% M_{max}; $p = 0.001$) and MG (23% vs. 14% M_{max}; $p = 0.02$). When data were averaged across groups during stair ascent, H-reflex amplitude in SOL increased from 15% M_{max} at the beginning of the stance phase to 29% M_{max} at mid-stance, then decreased to be 4% M_{max} in the swing phase. During stair descent, H-reflex amplitude was maximal (20% M_{max}) at the beginning of the stance phase, decreased to 5% M_{max} at the end of stance, and increased to 11% M_{max} in the swing phase. Similar adjustments were observed for the H reflex in MG for both ascent and descent. H-reflex modulation during gait cycle (relative to upright standing) is less pronounced in older adults ($p < 0.05$). However, no difference was observed between subgroups of young and older adults matched for H-reflex amplitude in upright standing. In both groups, H-reflex modulation was not associated with changes in background electromyographic activity.

Significance: This study indicates that the H reflex is modulated within the stair gait cycle during ascent and descent. Although its magnitude was slightly reduced, the overall modulation of the H reflex is not affected in healthy older adults.

1. Introduction

Previous work reported a depression of the Hoffmann (H) reflex amplitude in soleus (SOL) when standing upright compared with sitting [1], when standing at the top of a 3-step staircase compared with standing at the bottom of the staircase [2], and during the swing phase compared with the stance phase in gait cycle [3,4]. These modulations of H-reflex amplitude reflect variations in the net excitatory effect of group I afferents (mainly from monosynaptic projections of Ia afferents received by spinal motor neurones) that varies with the task characteristics. A decrease in H-reflex amplitude is usually observed during challenging motor tasks [5].

Ascending and descending stairs are among the most demanding and hazardous types of everyday activity [6]. The primary muscles that

generate the work to perform these actions are the knee extensors and ankle plantar flexors [7–9], with greater relative moment for ankle (85% of maximal joint moment) than knee (50%) joint [8]. The age-related decrease in maximal force capacity further increases the mechanical demands on ankle plantar flexors in older adults [8–10]. This stresses how critical is the control of plantar flexor muscles during stair ascent and descent. As the H-reflex amplitude decreases with ageing and its modulation depends on the characteristics of the postural task [11], it can be expected that stair ascent and descent involve specific modulation of the H reflex differs between young and older adults.

The aim of this study was to record H reflexes in SOL and medial gastrocnemius (MG) when young and older adults ascended and descended a 3-step staircase. Based on previous work investigating level walking [3,4], we hypothesized a lesser H-reflex amplitude in stair gait

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than in upright standing, and greater H-reflex amplitude. Furthermore, we expected a greater depression of the H-reflex amplitude during stair gait in older adults.

2. Methods

2.1. Subjects

Nineteen young (age: 24 ± 2yr; height: 170 ± 10 cm; mass: 65 ± 10 kg; 9 women) and eighteen older adults (69 ± 6yr; height: 170 ± 8 cm; mass: 74 ± 12 kg; 8 women) participated in two sessions (one familiarization, one experimental) after written informed consent was obtained. The project was approved by the local Ethics Committee. Subjects were asked to refrain from strenuous and unaccustomed physical activity in the 72 h preceding the experimental session and to refrain from caffeine consumption the day of the experiment. Individuals with Parkinson's disease, multiple sclerosis, diabetes, stroke or cardiac history, disease that impedes gait capacity or orthopaedic problems in the preceding 12 months were excluded from this study. Older participants were living at home and none of them suffered from neurological disease or took medications that could influence motor function [12].

2.2. Experimental set-up

Subjects stepped up and down a 3-step staircase that included two force platforms (OR6-6-2000, AMTI, USA) [2]. The signals from the force platforms were sampled at 100 Hz, A/D converted (Power 1401, 16-bit resolution, CED, UK). This staircase enabled the measurement of one entire gait cycle in ascent and descent. The stair gait cycle comprised a stance phase and a swing phase [13,14] distinguished from the vertical ground reaction forces (Fz signals). The gait cycle, during ascent, began with the right foot contacting the first step and ended with the right foot contacting the last step (Fig. 1). The stance phase was divided in three parts: 1/weight acceptance – initial contact of the right foot on the first step (two-leg stance); 2/push-up – ascending from one step to the next one (one-leg stance); 3/forward continuance – contact on the 2nd step (two-leg stance) by the left foot. The swing phase ended when the right foot was placed on the last step.

The gait cycle during descent began with the right foot contacting the first step (down from the top of the staircase) and ended with the right foot contacting the bottom of the staircase. The stance phase was divided into three parts: 1/weight acceptance – contact of the right foot on the first step (two-leg stance); 2/left foot clearance (one-leg stance); 3/controlled lowering with the left foot on the second step (two-leg stance). The swing phase ended when the right foot was placed on the floor.

2.3. Surface electromyogram

The surface electromyogram (EMG) was recorded from SOL, MG and tibialis anterior (TA) of the right leg with surface electrodes (silver-silver chloride electrodes of 8-mm diameter) in a bipolar configuration (inter-electrode distance: 2 cm) as previously described [5]. The EMG signals were amplified (1000x) and band-pass filtered (10–1000 Hz) prior to A/D sampling at 2 kHz (Power 1401, 16-bit resolution, CE, UK).

2.4. Electrical nerve stimulation

Electrical stimuli (1-ms duration) applied to the tibial nerve of the right leg were delivered via a constant current stimulator (DS7A, Digitimer, UK). The cathode position was determined by moving the cathode in the popliteal fossae until the site eliciting the largest H-reflex amplitude in the SOL at a given intensity was identified, the anode being placed just above the patella. The input-output relations for the H reflex and M wave were determined for each muscle during upright standing at the bottom of the staircase by progressively increasing the stimulus intensity in steps of 0.5–1.0 mA (5 stimulations/intensity) until the M-wave amplitude reached a plateau (M_{max}). The same intensities were used for the SOL and MG muscles. The fibular nerve of the right leg was stimulated by placing the cathode close to the head of the fibula to obtain an M wave in TA without activating the peroneal muscles, as checked by palpation, the anode being placed on the opposite side of the leg. The intensity was increased until M_{max}.

2.5. Knee and ankle joint angles

Knee and ankle joint angles of the right lower limb were obtained from 2D video recordings (Basler system, GER), and four led markers were placed on the lateral side of the limb: the middle of femoral diaphysis, the knee joint spacing, the lateral malleolus, and the head of the fifth metatarsal bone. Knee (full knee extension: 180°) and ankle (neutral ankle position = 90°; plantar flexion > 90°) joint angles were derived from the marker coordinates throughout the gait cycle by means of a specific software (Kinovea, 0.8.15; http://www.kinovea.org).

2.6. Experimental session

The stimulus intensity was chosen to produce a submaximal H reflex that was preceded by a small M wave in the ascending limb of the input-output relation of the H reflex in both SOL and MG, subjects performed 60 ascents and 60 descents at a self-selected pace, barefoot with the right leg as the leading leg. A train of six stimuli (2-Hz frequency) was delivered to the tibial nerve during each trial. No systematic depression of reflex amplitude in response to the 6 pulses within each stimulus train was observed, indicating a lack of homosynaptic depression [15]. The train was triggered 500, 600, 700, 800, 900 and 1000 ms in a counterbalanced order after an auditory signal indicating to start the ascent or descent. This procedure was used to obtain a sufficient number of H-reflex responses in each phase of the gait cycle for statistical analysis (Table 1). M_{max} was not recorded during stair ascent or descent as pilot experiments showed that it disrupted the stair gait cycle, in contrast with the selected intensity for H-reflex recordings.

In additional experiments, the EMG activity in the right leg muscles of 5 young (1 woman) and 5 older (2 women) subjects was also recorded during 10 ascents and descents, and during three MVC of ankle plantar flexor and dorsiflexor muscles performed with knee extended and ankle placed at 90° [1], to normalize EMG activity recorded during stair ascent and descents to corresponding MVC values.

Due to the potential influence of muscle length on H-reflex amplitude [16,17], we have controlled during preliminary experiments that ankle and knee joints angles within the range of those recorded during ascent and descent were not key parameters of the modulation of H-reflex amplitude during stair locomotion.

2.7. Data reduction

The peak-to-peak amplitude of the H reflexes and M waves was measured off-line from the raw EMG signals. To ensure consistency in stimulation conditions [3], only H reflexes preceded by an M wave with an amplitude that was within 2.5% M_{max} around the median value, calculated from all the stimulations in upright standing and stair ascent or descent, were included in the analysis (see Table 1). This procedure was applied independently for each task and muscle. No statistical difference in M-wave amplitude was observed between gait phases within a task (one-way ANOVA, $p = 0.52$). The average value of the vertical forces and rectified EMG (aEMG) for SOL, MG, and TA was measured over a 50-ms epoch preceding tibial nerve stimulation and averaged within each gait phase. The aEMG values were normalized to the corresponding M_{max} for age comparison purpose while vertical forces were normalized to subject's body weight.
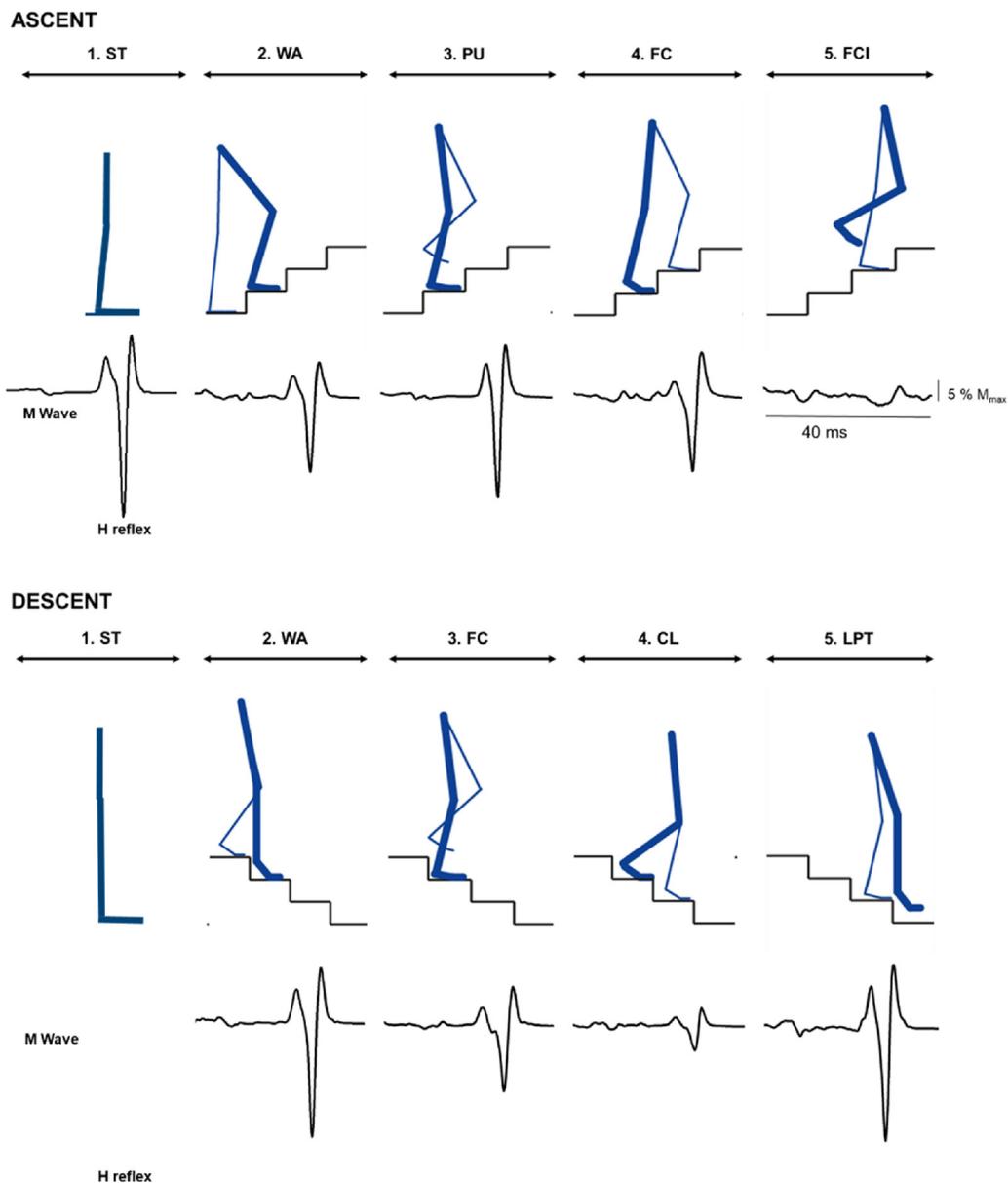
Fig. 1. Drawing of the different phases of the gait cycle in stair ascent and descent with the leading (bold line) and trailing leg (thin line). Electromyograms illustrated the H-reflex (average of 14 sweeps in each phase) from one young subject in the different phases of stair ascent and descent. ST: Standing; WA: Weight acceptance, PU: Push-up; FC: Forward continuance; FCl: Forward clearance; CL: Controlled lowering; LPT: Leg-pull through.

2.8. Statistics

Normality of the data were confirmed with Kolmogorov-Smirnov tests. Ascent and descent duration, and H-reflex and M_{max} amplitude during upright standing were compared between age groups with independent Student t-tests. Within each age group, one-way ANOVAs with repeated measures (stair gait phases) and Dunnet post-hoc tests were used to compare vertical forces, H-reflex amplitude, aEMG and joint angles in upright standing and gait cycle. Age effects were assessed by comparing the change (relative to upright standing) in H-reflex amplitude, aEMG, vertical ground reaction forces, and joint angles with two-way ANOVAs (age x gait phases) and Tukey post-hoc tests. The coefficient of determination (r^2) extracted from Pearson product–moment correlations was calculated for the relations between H-reflex amplitude and EMG data. The level of statistical significance was set at $p \leq 0.05$. Values are expressed as mean ± SD in the text and tables, and mean ± SEM in the figures.

3. Results

3.1. Upright standing

M_{max} amplitude was greater in young than older adults in SOL (11 ± 4 vs. 7 ± 4 mV; p = 0.004) and MG (9 ± 4 vs. 6 ± 3 mV; p = 0.04). H-reflex amplitude was greater in young than older adults for SOL (48 ± 21% vs. 26 ± 15% M_{max}; p = 0.001) and MG (23 ± 14% vs. 14 ± 10% M_{max}; p = 0.02).

3.2. Stair ascent

3.2.1. Kinetic and kinematic parameters

No significant age effect was observed for gait duration (young: 1.5 ± 0.2 s; older: 1.6 ± 0.2 s; p = 0.18), vertical ground reaction forces (p = 0.63), knee angle (p = 0.35) or ankle angles (p = 0.77) (Table 2).

aEMG. In all phases except foot clearance, SOL and MG aEMG was

Table 1

Preceding M-wave amplitude in SOL and MG and numbers of H-reflex responses recorded during of stair ascent and descent in young and older adults.

| | Ascent | | | Descent | |
	Young	Older		Young	Older
SOL					
ST (% Mmax)	6.6 ± 3.2	8.7 ± 4.0	ST (% Mmax)	6.8 ± 3.4	8.0 ± 2.8
WA (% Mmax)	6.4 ± 4.9	9.0 ± 7.2	WA (% Mmax)	6.2 ± 5.3	7.9 ± 6.9
PU (% Mmax)	6.6 ± 5.1	9.5 ± 7.2	FC (% Mmax)	6.3 ± 5.4	7.7 ± 6.9
FC (% Mmax)	5.8 ± 4.7	9.1 ± 7.6	CL (% Mmax)	5.2 ± 5.3	7.1 ± 6.7
FCl (% Mmax)	5.7 ± 5.4	9.3 ± 8.0	LPT (% Mmax)	6.5 ± 5.5	8.0 ± 7.1
MG					
ST (% Mmax)	8.0 ± 4.9	7.3 ± 3.0	ST (% Mmax)	9.5 ± 2.9	8.7 ± 3.4
WA (% Mmax)	7.1 ± 3.8	7.4 ± 4.3	WA (% Mmax)	11.6 ± 9.8	8.7 ± 4.8
PU (% Mmax)	8.3 ± 6.3	8.6 ± 6.3	FC (% Mmax)	11.0 ± 9.2	9.1 ± 5.7
FC (% Mmax)	8.5 ± 8.5	8.9 ± 6.5	CL (% Mmax)	10.4 ± 9.7	8.4 ± 5.5
FCl (% Mmax)	8.4 ± 5.1	8.5 ± 6.5	LPT (% Mmax)	10.7 ± 9.2	9.0 ± 5.3
H-reflex responses					
WA	15/5	14/5	WA	12/5	12/5
PU	19/7	25/10	FC	22/5	25/10
FC	14/5	14/5	CL	14/5	10/5
FCl	17/5	21/5	LPT	29/5	24/5

WA: Weight acceptance, PU: Push-up; FC: Forward continuance; FCl: Forward clearance; CL: Controlled lowering; LPT: Leg-pull through. The number of H reflexes is presented as average/minimum number.

greater ($p < 0.001$) than during upright standing in both groups (Fig. 2). Compared with upright standing, TA aEMG was greater in all phases except during pull-up ($p < 0.01$). aEMG for SOL, MG and TA ($p < 0.05$) was greater in older than young adults. When normalized to MVC (n = 5), aEMG remains greater in older than young adults for SOL (Mann-Whitney, $p = 0.05$) and TA ($p < 0.05$), and tended to be greater for MG ($p = 0.08$).

3.2.2. Evoked potentials

Compared with upright standing, H-reflex amplitude in SOL was less in all phases of the stair gait cycle in young adults ($p < 0.05$), and in weight acceptance ($p < 0.05$) and foot clearance ($p < 0.001$) in older adults (Fig. 3). Within the stair gait cycle, SOL H-reflex amplitude was greater in push-up than in weight acceptance ($p < 0.001$), forward continuance ($p < 0.001$) and foot clearance ($p < 0.001$) for both age groups (Fig. 3). H-reflex amplitude in MG was less ($p < 0.05$) in all phases of the stair gait cycle except during push-up ($p = 0.52$)

compared with upright standing in young adults (Fig. 3). In contrast, the H-reflex amplitude in MG was only significantly lesser during foot clearance in older adults ($p < 0.001$). Modulation of H-reflex amplitude was significantly associated between SOL and MG when both groups were pooled ($r^2 = 0.64$; $p < 0.01$). In contrast, there was no statistically significant association between H-reflex amplitude and aEMG.

The change in H-reflex amplitude during ascent relative to upright standing was less in older than young adults for SOL and MG ($p < 0.05$). However, the smaller H-reflex amplitude in older adults may have influenced its modulation. In agreement, the change (%) in H-reflex amplitude during weight acceptance, push-up and foot clearance was negatively associated with its amplitude during upright standing for SOL and MG in both groups ($r^2 > 0.76$; $p < 0.001$). Furthermore, when matching subgroups of young (n = 8, H-reflex: 31 ± 14% M_{max}) and older adults (n = 8, H-reflex: 31 ± 13% M_{max}) for H-reflex amplitude during upright standing, no age difference was

Table 2

Kinematics for the different stair gait phases and vertical forces during the stance phase in young and older adults.

| | Ascent | | | Descent | |
	Young	Older		Young	Older
Knee					
ST (°)	179.8 ± 2.8	179.5 ± 2.7	ST (°)	179.8 ± 2.8	179.5 ± 2.7
WA (°)	123.4 ± 8.9†	127.1 ± 9.1†	WA (°)	161.0 ± 6.7†	162.2 ± 9.0†
PU (°)	154.4 ± 8.2†	156.3 ± 8.7†	FC (°)	144.5 ± 7.2†	150.7 ± 8.1†
FC (°)	168.0 ± 7.2†	166.3 ± 7.8†	CL (°)	108.5 ± 10.5†	115.9 ± 9.7†
FCl (°)	115.3 ± 10.1†	119.9 ± 12.0†	LPT (°)	151.5 ± 10.3†	145.0 ± 13.6†
Ankle					
ST (°)	84.9 ± 3.1	84.9 ± 3.8	ST (°)	84.9 ± 3.1	84.7 ± 3.8
WA (°)	68.2 ± 6.4†	68.3 ± 8.4†	WA (°)	85.8 ± 9.0	89.6 ± 8.2†
PU (°)	73.6 ± 6.3†	75.3 ± 8.3†	FC (°)	67.7 ± 8.0†	72.3 ± 8.5†
FC (°)	87.8 ± 9.5	91.9 ± 9.2†	CL (°)	73.1 ± 8.4†	70.5 ± 10.2†
FCl (°)	81.2 ± 7.5†	80.1 ± 8.4†	LPT (°)	97.1 ± 8.4†	97.3 ± 6.9†
Vertical force					
WA (BW)	0.38 ± 0.17	0.43 ± 0.20	WA (BW)	0.40 ± 0.18	0.51 ± 0.26$
PU (BW)	0.89 ± 0.08 *	0.90 ± 0.07 *	FC (BW)	0.74 ± 0.29 *	0.94 ± 0.08 *$
FC (BW)	0.76 ± 0.24 *	0.75 ± 0.27 *	CL (BW)	0.45 ± 0.20	0.60 ± 0.17$

ST: Standing; WA: Weight acceptance, PU: Push-up; FC: Forward continuance; FCl: Forward clearance; CL: Controlled lowering; LPT: Leg-pull through; BW: Body weight; † denotes phase main effect compared to upright standing ($p \leq 0.05$); * denotes significant difference compared to WA; $ denotes significant difference between young and older adults.
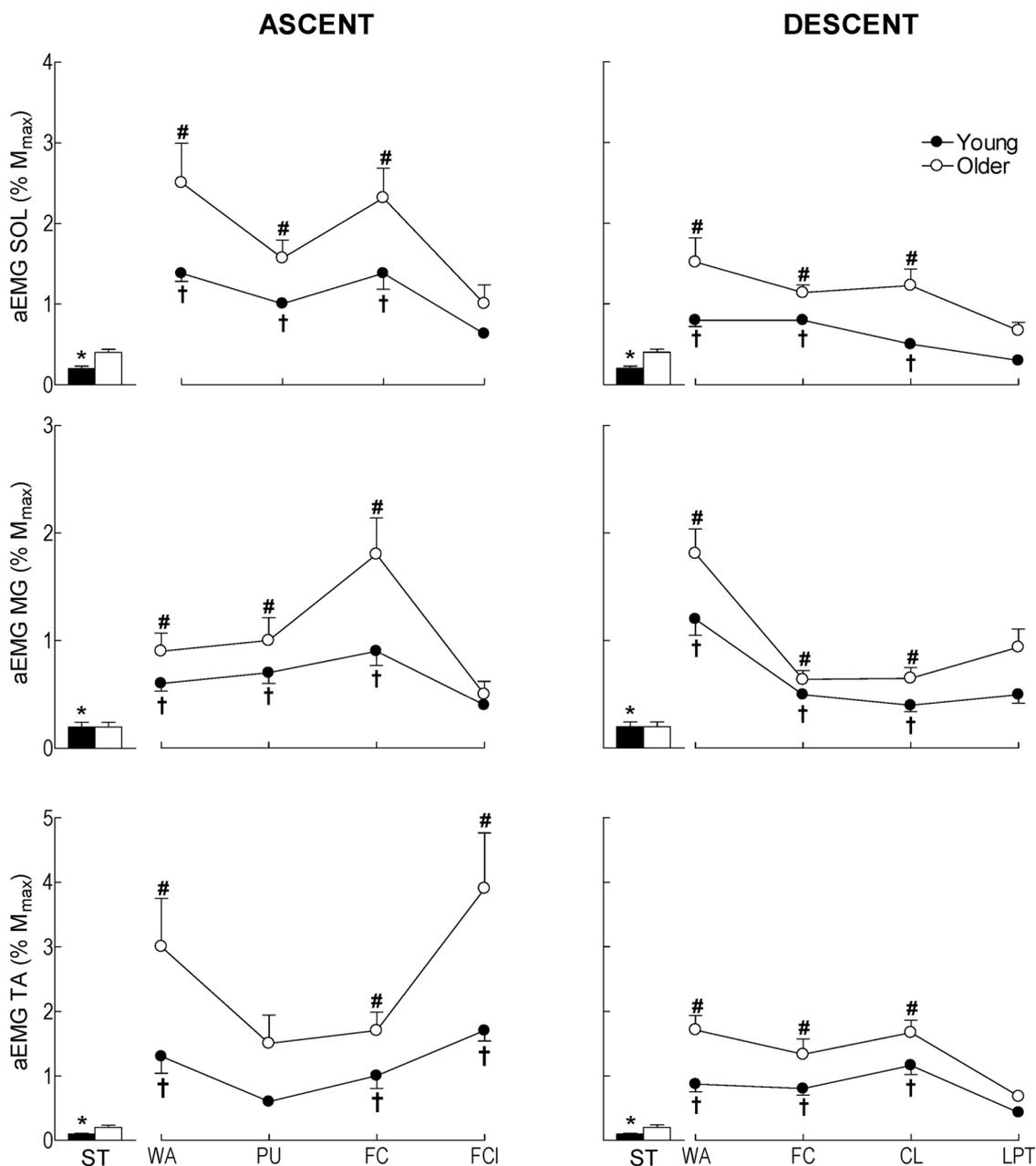
Fig. 2. Average value of rectified EMG (aEMG) for the soleus (SOL; top panel), gastrocnemius medialis (MG; mid panel) and tibialis anterior (TA; bottom panel) in young (filled bars and circles) and older (open bars and circles) adults during upright standing and different phases of stair ascent (left panel) and descent (right panel). For each muscle, EMG values are expressed relative to the corresponding M_{max}. ST: Standing; WA: Weight acceptance, PU: Push-up; FC: Forward continuance; FCl: Forward clearance; CL: Controlled lowering; LPT: Leg-pull through. An age main effect ($p < 0.05$) indicates that EMG activity was greater in older than young adults for the three muscles investigated. † and # denote phase main effect compared to upright standing ($p \leq 0.05$) in young and older group, respectively. Data are mean ± SE.

observed ($p = 0.69$).

3.3. Stair descent

3.3.1. Kinetic and kinematic parameters

The gait-cycle duration was similar between young (1.4 ± 0.2 s) and older adults (1.4 ± 0.2 s)($p = 0.95$), whereas the vertical ground reaction forces were greater for older adults (age main effect: $p < 0.01$)(Table 2). No significant age effect was observed for knee ($p = 0.71$) and ankle ($p = 0.77$) angles.

aEMG. In all phases except the leg-pull through, SOL and MG aEMG was greater ($p < 0.001$) than in upright standing for young and older adults (Fig. 2). Compared with upright standing, TA aEMG was greater

in all phases except for leg-pull through ($p < 0.001$). When normalized to MVC aEMG (n = 5), aEMG remains greater in older than young adults for SOL ($p = 0.03$), MG ($p = 0.01$) and TA ($p = 0.05$).

3.3.2. Evoked potentials

H-reflex amplitude in SOL and MG was less in all stair gait phases than in upright standing for young and older adults. Within gait cycle for both young and older adults, H-reflex amplitude in SOL was maximal in weight acceptance ($p < 0.001$), decreased in foot clearance ($p < 0.001$) to reach a minimum in controlled lowering ($p < 0.001$) and then increased slightly in leg-pull through ($p < 0.001$)(Fig. 3). For MG, H-reflex amplitude was depressed in all gait phases compared with upright standing in young adults ($p < 0.05$), whereas it was
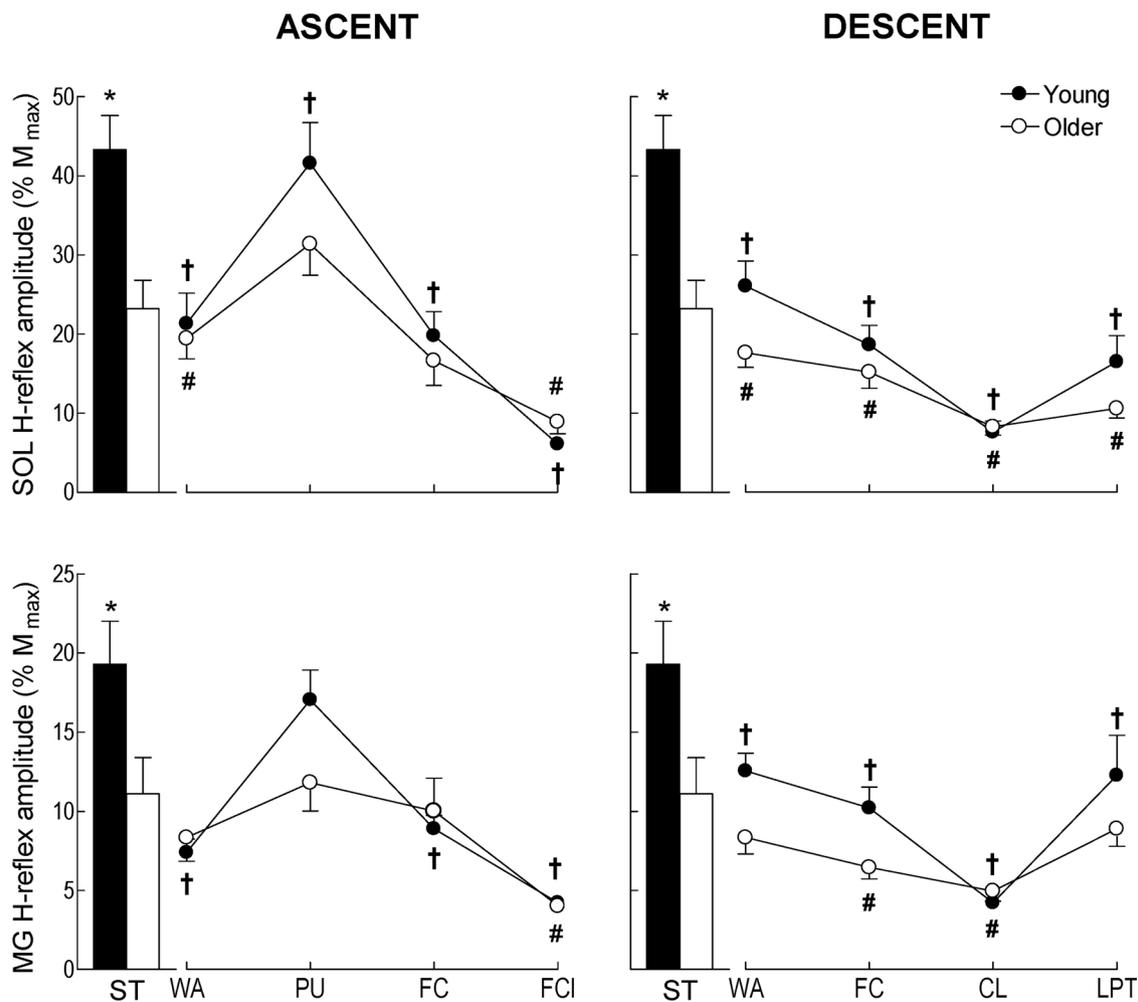
ASCENT

DESCENT

Fig. 3. Average values of H-reflex amplitude expressed as percentage of M_{max} recorded in soleus (SOL; top panel) and gastrocnemius medialis (MG; bottom panel) in young (filled bars and circles) and older (open bars and circles) adults during upright standing and different phases of stair ascent (left panel) and descent (right panel). ST: Standing; WA: Weight acceptance, PU: Push-up; FC: Forward continuance; FCl: Forward clearance; CL: Controlled lowering; LPT: Leg-pull through. † and # denote phase main effect compared to upright standing ($p \leq 0.05$) in young and older group, respectively. Data are mean ± SE.

significantly less in forward continuance ($p < 0.001$) and controlled lowering ($p < 0.001$) in older adults (Fig. 3). Modulation of H-reflex amplitude was significantly associated between SOL and MG when both groups were pooled ($r^2 = 0.68$; $p < 0.01$, both groups combined). No association ($p > 0.05$) was found between H-reflex amplitude and aEMG.

As observed in stair ascent, the extent of H-reflex modulation was greater in young than older adults for SOL and MG (age main effect, $p < 0.001$), and a negative relation was observed between H-reflex amplitude in upright standing and its change during gait ($r^2 = 0.50$, $p = 0.02$). No age effect was observed in the modulation of the H reflex ($p = 0.58$) for young and older adults matched for H-reflex amplitude.

4. Discussion

4.1. H reflex during the stair gait cycle

An overall decrease in H-reflex amplitude was observed during ascent and descent compared with upright standing in young, with a similar trend in older adults. This result parallels the decrease in H-reflex amplitude when changing from upright standing to walking [3]. Furthermore, the H-reflex modulation during stair ascent resembles those observed during level walking [3], with a maximal value in the middle of the stance phase and a minimum value during the swing phase. This modulation may reflect a facilitating effect of group I afferents to assist

the push-up phase and a greater feedforward control of the ankle angle during the swing phase to shape foot trajectory.

In contrast to level walking or stair ascent during which the shortening of the active muscles contributes to the propulsion of the body, leg muscles rather contract while lengthening during stair descent [7,10]. As H-reflex amplitude is typically depressed during lengthening contractions [18,19], the difference in H-reflex modulation between ascent and descent may be at least partially attributed to the contraction type performed by the plantar flexor muscles. The increase in H-reflex amplitude during the swing phase, however, could reflect an increased contribution of group I afferents input to prepare the next foot contact with a step [7].

Interestingly, the H-reflex modulation appears mainly independent of the background EMG activity in both ascent and descent, in contrast with level walking [3]. This may reflect a greater control of Ia afferents through presynaptic inhibition during the stair gait compared with level walking. This is consistent with the increased role of supraspinal structures in the control of upright standing during challenging balance tasks [20].

It is worth noting that the modulation of the H-reflex within corresponding phases of stair gait differed qualitatively between ascent and descent. As reported by Ridgway et al. [21], the net joint moment for the ankle during the stance phase does not really differ between ascent and descent, and between young and older adults. The profile of H-reflex modulation therefore cannot only account for specific

mechanical requirement of the two tasks (ascent and descent; [21,22], but should also reflect differences in muscle actions (see above) and how the two tasks challenge the dynamic postural stability [23,24]. Overall, the results highlight that the net excitatory effect of group I afferents on homonymous spinal motor neurones is specifically modulated to the requirement of stair ascent and descent.

4.2. Healthy ageing

Ascent and descent durations, and knee and ankle range of motion were similar between young and older adults, in agreement with previous studies [8,9,25]. The aEMG of leg muscles was significantly greater in older than young adults during stair ascent and descent, even when EMG amplitude was normalized to M_{max} or aEMG recorded during MVCs, as reported during upright standing [1,18], level walking [4], and stair ascent and descent [25]. The greater EMG activity in older than young adults suggests that the former operated closer to their maximal force capacities during both stair ascent and descent [8,9], without adopting the safer strategy of reducing knee and ankle joint moments [8,9].

M_{max} and H-reflex amplitudes were lesser in older adults, likely due to structural and functional changes [11,26]. Nonetheless, the overall modulation of the H reflex during stair ascent and descent was similar for both groups. We recently reported a similar decrease in H-reflex amplitude in young and older adults when they stood at the top compared with the bottom of the staircase [2]. The present study extends these findings by showing that H-reflex modulation differs between stair ascent and descent but is not influenced by healthy ageing.

In conclusion, this study indicates that H-reflex amplitude varies within the stair gait cycle for both young and older adults. This observation suggests that the net excitatory effect of group I afferents on spinal motor neurones of plantar flexor muscles is specifically modulated with the characteristics of stair gait. Critically, even if its magnitude was slightly reduced, the overall modulation of the H reflex is not affected in healthy older adults.

Conflict of interest

Acknowledgments

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