

# EFFECTS OF LATERAL STABILIZATION AND ARM SWING ON METABOLIC COST OF WALKING IN YOUNG AND ELDERLY ADULTS

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## INTRODUCTION

Elderly adults consume more metabolic energy for walking than young adults across a range of speeds (Martin et al., 1992). It is possible that the elevated energy consumption by elderly adults is related to decreased stability during walking. In young adults, it is known that the metabolic cost of lateral stabilization accounts for as much as 6% of the cost of walking (Donelan et al., 2004). Elderly adults appear to be less stable during walking than young adults (Winter et al. 1990) and, thus, may have a greater metabolic cost of lateral stabilization. Moreover, because instability during walking may be partially counteracted by arm swing (Shibukawa et al., 2001), we examined its role in determining the metabolic cost of walking.

This study tests two hypotheses: 1) elderly adults consume more metabolic energy during walking than young adults because they have a greater metabolic cost of lateral stabilization, and 2) arm swing reduces the metabolic cost of stabilization during walking in young and elderly adults.

## METHODS

Twelve healthy elderly adults ( $74.5 \pm 2.9$  years; mean  $\pm$  s.d.) and twelve healthy young adults ( $22.7 \pm 3.7$  years) performed seven minute trials of treadmill walking at  $1.3 \text{ m s}^{-1}$ . We examined the effect of external stabilization on metabolic cost and kinematics during walking with and without arm swing.

We provided external lateral stabilization by applying bilateral forces (10% body weight) to the walking subject using a device similar to that in Donelan et al. (2004). This device consisted of two elastic cords attached to the left and right sides of the waist via a padded belt that allowed normal arm swing. Each cord included a 14 m long nylon string in series with 0.5 m of hollow latex rubber tubing. Given this long length, small deviations from the intended cord orientation created negligible vertical or horizontal (fore-aft) forces applied to the subject. The entire system produced an effective spring constant of approximately  $1900 \text{ N m}^{-1}$  and minimal damping ( $26 \text{ N s m}^{-1}$ ).

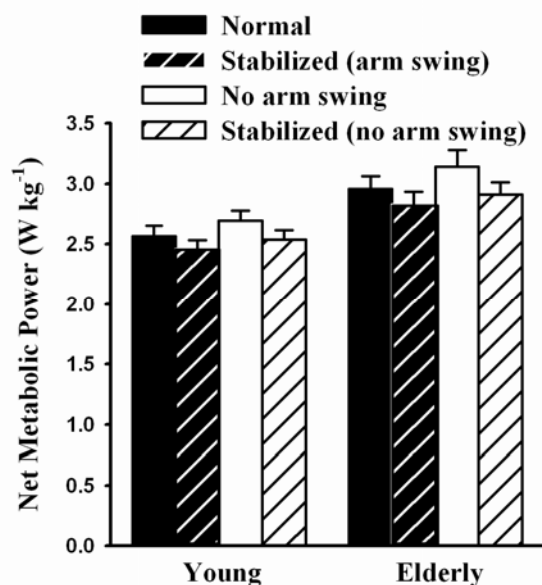
Metabolic power consumption was determined for the last two minutes of each trial using indirect calorimetry and standard equations (Brockway 1987). We calculated net metabolic power (W/kg) by subtracting standing metabolic power from gross metabolic power and dividing by body mass. We also measured step frequency and step width using high-speed video (200 Hz).

## RESULTS AND DISCUSSION

External stabilization reduced metabolic power consumption to a similar extent in young and elderly subjects (6-7%;  $p < 0.0001$ ; Fig. 1) when they walked without arm swing. Moreover, for both groups walking without arm swing, external stabilization reduced step width by 63-67% ( $p < 0.0001$ ) and its variability by 64-71% ( $p < 0.0001$ ). Finally, when subjects walked

with normal arm swing, external stabilization affected metabolic power consumption and step width less than when they walked without arm swing (Fig. 1).

These results show that young and elderly adults have a similar metabolic cost of lateral stabilization during walking. External stabilization allowed subjects to reduce step width and step width variability because walking required less active control of stability. These changes probably reduced the individual limb work performed by the subjects and thereby reduced metabolic cost (Donelan et al., 2001).



**Figure 1:** Net metabolic power for young and elderly subjects. External stabilization reduced metabolic power more when subjects walked with no arm swing than with arm swing. Also, eliminating arm swing increased metabolic power to a greater extent without external stabilization than with it.

Eliminating arm swing increased metabolic power consumption to a similar extent in young and elderly subjects when they walked without external stabilization (5-6%;  $p < 0.014$ ; Fig. 1). In contrast, when

either group walked with external stabilization, eliminating arm swing did not significantly affect metabolic power ( $p = 0.160$ ).

These findings show that external stabilization compensates for arm swing elimination. This observation suggests that arm swing reduces the metabolic cost of walking in young and elderly adults by contributing to stabilization.

## SUMMARY/CONCLUSIONS

Elderly adults have a similar metabolic cost of lateral stabilization as young adults. Thus, the high metabolic cost of walking in elderly adults is likely due to other factors, such as greater muscle force generation for supporting body weight. Moreover, arm swing reduces the metabolic cost of walking in young and elderly adults likely by contributing to stability.

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