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Do older adults have impaired stability control during adaptive gait?

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ABBREVIATIONS

AP	anterior-posterior
BoS	base of support
CoM	center of mass
ML	medial-lateral
MoS	margin of stability
XCoM	extrapolated center of mass

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Adaptive gait involves the ability to adjust one’s basic gait pattern according to the demands of the environment or the task. This ability is essential to maintain stable gait in daily life, as routinely, we need to deal with dual tasks, obstacles and rough terrains. Although gait stability can be measured using different metrics, a nowadays common biomechanical measure is the margin of stability (MoS).[1] The distance between the extrapolated center of mass (XCoM) and the boundaries of the base of support (BoS) defines the MoS.[1] The XCoM reflects the location of the center of mass (CoM) based on its actual velocity, as the maintenance of stability depends not only on the position of the CoM but also on its velocity.[1] While the XcoM is within the boundaries of the BoS (i.e., positive MoS values), the system is dynamically stable, whereas a negative MoS would lead to falling. During walking, this assumption is true in the medial-lateral (ML) direction, as a negative MoS would require a subsequent cross-step to remain stable. In the anterior-posterior (AP) direction, however, a negative MoS induces a forward loss of balance that can be recovered by making a next step. In this case, a less negative value is usually accepted as indicative of better stability control. The MoS has become an accessible parameter, as it represents an objective measure of stability, and it is relatively simple to obtain during gait in different environmental contexts.

In turn, it has been widely accepted that older adults have impaired stability control during walking, particularly during adaptive gait, which would reflect in the high prevalence of falls in this population.[2] Nevertheless, the crescent use of the MoS has shown that stability control is not necessarily impaired when older adults adapt their gait to environmental challenges. Several studies have shown contradictory findings in this regard. During the double support phase, while descending stairs, the AP MoS was similar between younger and older adults; however, during the single support phase, the older adults did show a more negative AP MoS than younger adults.[3] When walking and turning the head, younger and older adults exhibited the same MoS.[4,5] Different studies investigating adjustments after unexpected perturbation during walking have shown that the initial responses to these perturbations are inferior in older compared to younger adults, but the adaptation potential related to perturbations does not decrease with age.[6,7] Similarly, Roeles et al.[8] found no difference between younger and older adults for both AP and ML MoS following unexpected perturbations. A meta-analysis furthermore showed that younger and older adults exhibited similar adaptability after repeated mechanical locomotor perturbations.[2] These results indicate that older compared with younger adults are similarly responsive to short-term interventions to improve their gait stability. In fact, in conditions of split-belt adaptation during treadmill walking healthy older adults effectively increased cadence through decreased double support time and increased ML MoS, as an adaptive strategy to control stability during such challenging locomotor tasks.[9]

Altogether, these results do not fully support the conventional view that healthy older adults have impaired control of stability during adaptive gait. Even when considering the analysis of local dynamic stability (e.g., Lyapunov exponent), the results are inconsistent across studies.[4,8] Aging is a multifactorial process and, therefore, different factors can influence stability control. Although aging is associated with structural changes that can affect postural control, healthy older adults appear to be less susceptible to the deleterious effects of structural changes as normally thought. Healthy older adults seem to maintain the ability to functionally compensate for those structural losses in order to ensure stability. For instance, changes in spatial-temporal walking parameters in healthy older adults may not necessarily exhibit a worsening in stability control. Rather, it may indicate necessary strategies to ensure stability when performing difficult walking tasks.[9] A recent study using the muscle synergy concept reported that older adults imply wider, less unstable and less complex basic activation patterns to ensure robust stability control.[10] The fact that healthy older adults are able to compensate and then minimize or even eliminate differences in stability control compared to younger adults suggests that adaptive gait can be preserved to a large extent with successful aging. Therefore, age itself does not seem to be a sufficient condition to impair stability control critically. Other aspects beyond age should be taken into account and may include genetics, cognitive functioning, and lifestyle. Future studies should focus on identifying compensation factors potentially affecting stability control in healthy older adults while walking in order to clarify underlying mechanisms for maladaptive gait and develop clinical tools to pinpoint these factors.

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