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Original Study

Is Trunk Posture in Walking a Better Marker than Gait Speed in Predicting Decline in Function and Subsequent Frailty?

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ABSTRACT

Background: Many recent guidelines and consensus on sarcopenia have incorporated gait speed and grip strength as diagnostic criteria without addressing early posture changes adopted to maintain gait speed before weakness is clinically evident.
Objectives: Older adults are known to compensate well for declining physiological reserve through environmental modification and posture adaptation. This study aimed to analyze and identify significant posture adaptation in older adults that is required to maintain gait speed in the face of increasing vulnerability. This would be a useful guide for early posture correction exercise interventions to prevent further decline, in addition to traditional gait, balance, and strength training.
Design: A community-based cross-sectional study.
Setting and Participants: The participants comprised 90 healthy community-dwelling Chinese men between the ages of 60 and 80 years and 20 Chinese adults between the ages of 21 and 50 years within the normal BMI range as a comparison group.
Measurements: All the participants underwent handgrip strength testing, 6-minute walk, timed up-and-go (TUG), and motion analysis for gait characteristics. Low function was characterized by slow walking speed (<1.0 m/s) and/or slow TUG (>10 seconds), whereas low strength was determined by hand grip dynamometer testing (<26 kg). The degree of frailty was classified using the Canadian Study for Health and Ageing Clinical Frailty Scale (CSHA-CFS) to differentiate between healthy and vulnerable older adults.
Results: As expected, the vulnerable older adults had lower functional performance and strength compared with the healthy older adults group. However, a significant number demonstrated posture adaptations in walking in all 3 groups, including those who maintained a good walking speed (>1.0 m/s). The extent of such adaptation was larger in the vulnerable group as compared with the healthy group.
Conclusion: Although gait speed is a robust parameter for screening older adults for sarcopenia and frailty, our data suggest that identifying trunk posture adaptation before the onset of decline in gait speed will help in planning interventions in the at-risk community-dwelling older adults even before gait speed declines.

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With the aging of the population and the rising costs of health care, many countries are refocusing health care policy on health promotion and disability prevention among older people. It has been argued that efforts aimed at identifying at-risk groups of older people so as to provide early intervention and/or multidisciplinary case management should be done at the level of general practice via adoption of a clinical paradigm based on the concept of frailty, which fits well with the biopsychosocial model of primary care. However, this ideal has exposed the lack of frailty metrics that are appropriate for primary care. Indeed, family physicians and community practitioners are still in need of easy instruments for identifying and estimating frailty early.

Fried and Walston[1] had hypothesized a "cycle of frailty" that was consistent with clinical signs and symptoms. This hypothesis indicated reduced levels of nutrition and activity, age-related musculoskeletal changes, and disease as being the possible precursors to loss of muscle mass as seen in the onset of sarcopenia, which then progressed to decreased walking speed, strength, and power along with respiratory and metabolic changes. In keeping with this hypothesis, various researchers have tried to develop simplified protocols to reliably identify frailty and associated sarcopenia, with the result that a strong consensus has emerged around the use of walking or gait speed as the most reliable and easy to administer marker.[2–4] Gait speed is now considered a strong predictor of a wide range of outcomes in older adults, including falls and fractures, hospitalization, cognitive decline, and mortality.[5,6] Hence, many recent guidelines and consensus definitions of sarcopenia have been based on gait speed, but without addressing posture adaptation to maintain gait speed in the face of weakness or joint stiffness.

With aging, older adults compensate for general decline through environmental modification and posture adaptation. Lord et al[7] demonstrated that to be dwelling in the community, one must maintain a walking speed close to 1.14 m/s. Kang and Dingwell[8] also showed that the young and elderly both reported the same preferred walking speed. Because the individuals in this study were all community dwelling, the obvious question was whether they were adapting posture and gait to maintain a reasonable gait speed. It is possible that those who developed early adaptations in posture were more prone to early functional deficits and, hence, at a greater risk of rapid progression to sarcopenia and frailty. These would represent, more accurately, the "transition to frailty and sarcopenia" group in the otherwise healthy, community-dwelling group of Chinese men. Such an adaptation-mediated compensation for declining gait speed is not very well addressed in the literature at the moment.

The objective of this prospective, cross-sectional community study was, therefore, to identify early adaptations in posture during walking that may precede actual decline in gait speed among healthy community-dwelling Chinese men. A progression pathway from posture adaptation to gait adaptation leading to decline in functional measures such as gait speed and timed up-and-go (TUG) measures was also hypothesized after data analysis.

Methods

The study team recruited 90 community-dwelling older Chinese adults between the ages of 60 and 80 years with body mass index (BMI) in the normal range (18.5–23.5 according to Asian standards). An additional 20 adults were recruited in the 21 to 50 years age group to act as a reference comparison. Their function was evaluated using handgrip strength testing, 6-minute walk, TUG, and 6-camera motion analysis for gait characteristics. Parameter cutoffs were initially benchmarked using data from published literature by the Asian Working Group on Sarcopenia for Chinese subjects[9] and modified based on data obtained from this study. Low function was characterized by slow walking speed (<1.0 m/s) and/or slow TUG (>10 seconds), whereas low strength was determined by handgrip dynamometer testing (<26 kg). The degree of frailty was classified using the Canadian Study for Health and Ageing Clinical Frailty Scale (CSHA-CFS)[10] to differentiate between healthy and vulnerable elderly.

Rockwood et al[10] proposed the CSHA-CFS, a global clinical measure of fitness and frailty in elderly people (CSHA 1: Very fit; CSHA 2: Without active disease but less fit than CSHA 1; CSHA 3: Well, with treated and well-controlled comorbid disease; CSHA 4: Apparently vulnerable, not dependent but complain of being "slowed up" and have disease symptoms). The CSHA-CFS was derived from a 5-year prospective cohort study. This 7-point scale was then further translated by Chan et al[11] as the Chinese-Canadian physician version and used to validate a telephone version. We used the CSHA-CFS physician version algorithm to categorize our participants into 3 groups. Group 1 was healthy older adults (CSHA 1 and 2, n = 41), group 2 was intermediate-risk older adults (CSHA 3, n = 33), and group 3 consisted of the vulnerable older adults (CSHA 4, n = 16). This was appropriate because all the participants were community dwelling with no evidence of significant functional impairment or dependence, which may have placed them in the frailer categories of CSHA 5 to 7. None of the recruited individuals remembered having a fall in the past 12 months. Those with chronic obstructive pulmonary disease and cardiac pacemakers were screened out, as were those on steroid medication and growth hormones. Further, blood samples were drawn to record free testosterone, growth hormone levels, and insulin-like growth factor (IGF-1). This was done to further qualify the frailty classification, as all 3 blood markers are associated with frailty in published literature.[12–14]

To analyze joint and limb segment kinematics, each participant was fitted with 31 reflective anatomical (25-mm diameter) markers, positioned according to the standard Plug-in Gait Marker Set, along with 5 additional markers to track the head and 1 marker on the chin. Participants were asked to walk along a walkway 6 meters in length with 2 force plates, recording at least 3 trials per participant. Six infrared cameras (Vicon MX system; Oxford Metrics, Oxford UK) placed around the walkway recorded the coordinates of these reflective markers at 200 Hz in 3 dimensions. The kinematics data were smoothed using a Woltring filter with a mean squared error of 20. The software for data collection was the Vicon Workstation 5.1 and the data analysis was performed with Vicon Polygon 3.1.

Ethics approval was obtained from Domain-Specific Review Board of National Healthcare Group, Singapore. All participants provided signed consent.

Data Analysis

At first, the strength and function data were used to verify that the clinical frailty classification using the CSHA-CFS was accurate and was reflected in the strength and function measures. We analyzed the walking speed as measured in both 6-minute walk and camera-based motion analysis study separately. The latter was performed in a laboratory and involved only a few footfalls. It has been reported to be a good measure for assessing frailty. However, the community-dwelling participants in this study tended not to walk at their normal pace in the gait laboratory and appeared to walk more normally (and faster) while doing a 6-minute walk in the gym. Both the measures were analyzed, as we did not know the extent of gait difficulties that might be present in the individuals recruited from the community.

The joint and limb kinematics of each participant were analyzed using the motion analysis data. For trunk posture, markers placed at C7 on spinous process on the back, shoulders (acromion process), sternum, anterior superior iliac spine (ASIS), and posterior superior iliac spine were studied to identify posture variations in pitch and roll during walking. The Plug-in Gait kinematic model from the Vicon Polygon software was used to measure shoulder offset in the X-direction (direction of walking) during 2 consecutive sets of left and