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The association between energy cost of walking and physical function in older adults

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ABSTRACT

To assess the association between energy cost of walking and self-report of function, independent of comorbidity and gait speed, in older adults with mobility limitations. This cross-sectional observational study was conducted within an ambulatory clinical research training center. Forty-two older adults, age 65 and older, with slow and variable gait participated. Function was assessed using the Late Life Function and Disability Index-Basic Lower Extremity Subscale, while energy cost of walking was derived by standardizing the mean oxygen consumption recorded during physiological steady state by gait speed. Comorbidity and gait speed were collected as co-variates. Pearson's r correlation coefficient and regression analyses were used to assess the relationship between energy cost and function. Energy cost of walking was significantly correlated with self-reported function (Pearson's $r = -0.50$, $p < 0.001$); furthermore, energy cost of walking explained an additional 17% ($p = 0.002$) of the variance in self-reported function above and beyond the variance explained by comorbidity and gait speed combined. Energy cost of walking is emerging as another significant factor related to functional performance among older adults, even after controlling for comorbidity and gait speed – robust variables known for their strong contributions to function. Knowledge of and attention to the efficiency of how one moves (high energy cost of walking) may enhance rehabilitation efforts to further reduce "functional burden" in older adults.

1. Introduction

Remaining functionally independent within the community and maintaining a high quality of life are two common goals among older adults, often coinciding with aging. However, certain physiological changes that occur with aging, such as decreasing aerobic capacity and increasing energy cost of walking, may significantly challenge an older adult's ability to maintain such goals. Progressive decline in aerobic capacity, the maximum amount of oxygen (and thus energy) available for use by the body at any one time, is thought to negatively impact independence and quality of life by reducing the total energy available to the body for performing basic and advanced daily activities (Fleg et al., 2005). With reduced maximum levels of "energy" available for routine function, activities such as walking may comprise a greater proportion of the available energy – therefore reducing the reserve available to complete additional activities (Fig. 1A) (Ferrucci et al., 2000; Schrack, Simonsick, & Ferrucci, 2010b).

While the age-related decline in aerobic capacity *reduces* the total energy available for older adults to complete daily tasks, age-related change in the way activities of daily living are performed – *increases* the energy demand from the body during task performance. Age-related gait abnormalities are known to increase walking energy expenditure – the energy cost of walking (Waters & Lunsford, 1985; Waters, Barnes, Husserl, Silver, & Liss, 1988; Waters, 1992; Wert, Brach, Perera, & VanSwearingen, 2010). Increased energy cost of walking has the potential to yield adverse functional consequences for older adults, as the amount of energy used during walking comprises a greater portion of the total energy available. As such, older adults may experience usual walking as both a more intense physical activity and a fatigue-producing daily activity. The greater intensity and fatigueability of walking emerges as the reserve between energy that is available and that which is being used by the body-narrows (Fig. 1B). This is of great concern as daily walking-related activities perceived to cause greater fatigue and exhaustion are more apt to be reduced or discontinued (Hortobagyi, Mizelle, Beam, & DeVita, 2003; Vestergaard et al., 2009). Age-related higher energy cost of walking has

Abbreviation: LLFDI-BLE, Late Life Function and Disability Instrument-Basic Lower Extremity Subscale.

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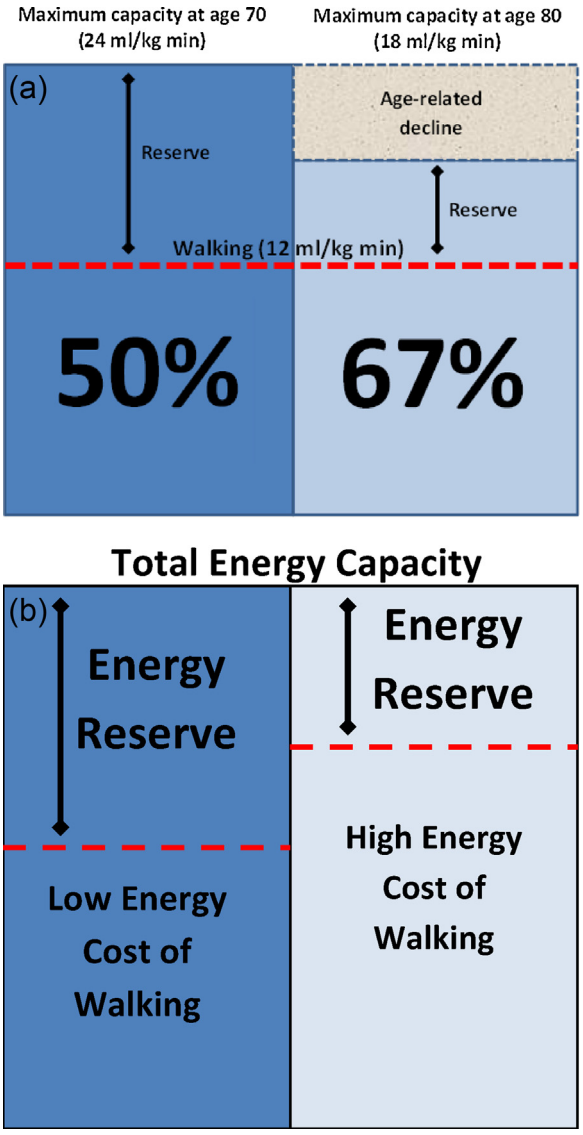

Fig. 1. (A) Impact of aging on aerobic capacity. At age 80, the total available energy for use is lower than that at age 70. Therefore, tasks such as walking comprise a greater proportion of the total aerobic capacity in older adults (67% versus 50%); the reserve (energy) available for completing additional activities is reduced. (B) Potential impact of high energy cost of walking on energy reserves. Higher energy cost of walking utilizes a greater proportion of the total energy capacity. The higher energy cost of walking reduces the reserve energy available to perform additional activities.

the potential to lead to a decline in overall activity and greater risk of future mobility disability.

Although researchers have alluded to the contribution of energy cost of walking to functional decline in older adults (Hortobagyi et al., 2003; Hortobagyi, Finch, Solnik, Rider, & DeVita, 2011; Malatesta et al., 2003; VanSwearingen et al., 2009), few if any studies have directly assessed such a relationship, especially among vulnerable older adults who have begun to show signs of mobility limitation. Therefore, the purpose of this study is to assess the cross-sectional relationship between energy cost of walking and function in a sample of community-dwelling older adults with mobility limitation (slowed and variable gait). We hypothesize that energy cost of walking will explain a unique portion of the variance in function of older adults, beyond that explained by robust variables known to be associated with function (gait speed and comorbidity). Specifically, we expect older adults with high energy cost of walking compared to low cost, to report poorer physical function.

2. Methods

Data used for this cross-sectional study were collected as part of a baseline assessment (prior to randomization) for a 12-week randomized, controlled clinical trial comparing two forms of therapeutic activity to improve energy cost of walking and mobility in older adults with evidence of walking difficulty (VanSwearingen et al., 2009). This study was approved by the University of Pittsburgh Institutional Review Board, and all participants provided informed consent prior to participation.

2.1. Participants

Participants were recruited from the Pittsburgh Pepper Registry, a registry of older adults who have expressed an interest in participating in mobility research. Eligible subjects were community-dwelling older adults ($\geq$65 years) with slow ($0.6 \leq$ speed ≤ 1.0 m/s) and variable gait (step length variability $> 4.5\%$ coefficient of variation or step width variability of $<7\%$ or $>30\%$), as determined during baseline testing using a computerized walkway (GaitMat II[1]). Gait speed and variability of this type and magnitude have been shown to place older adults at greater risk for falls and future mobility disability (Brach, VanSwearingen, Newman A, & Studenski, 2005; Maki, 1997). Eligibility was also dependent on the ability to ambulate independently with or without a cane; physician approval to participate in a low to moderate intensity exercise program; and a Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) of 24 or greater. Only individuals with complete baseline data for all variables of interest (age, gait speed, comorbidity, function, and energy cost of walking) were included in the analyses.

2.2. Measures

2.2.1. Physical function

The Late Life Function and Disability Instrument-Basic Lower Extremity Subscale (LLFDI-BLE) (Haley et al., 2002; Sayers et al., 2004), a self-report questionnaire, was used to assess physical function in older adults. The BLE subscale reports the difficulty in completing 14 activities which represent common daily activities performed by older adults, and primarily involves standing and essential walking (e.g. walk around one floor of home, get into and out of car, step up and down from a curb, go up and down a flight of stairs, stand up from a low, soft couch). Scores on the BLE subscale range from 0 to 100, where higher scores indicate better function. The LLFDI has been shown to be a reliable.(ICC (Intra-class correlation coefficient) = 0.91–0.98) and valid measure of function in older adults (Haley et al., 2002; Sayers et al., 2004).

2.2.2. Energy cost of walking

Energy cost of walking – The energy cost of walking is a measure that reflects, via a measure of oxygen consumption, the energy used for all bodily actions during walking (Boyd et al., 1999), and is defined as the mean rate of oxygen consumption standardized by gait speed (Waters, 1992). Prior to baseline testing, all participants completed required practice walking sessions on a treadmill in order to become familiar and comfortable with treadmill walking. Once familiarization was complete, participants completed the baseline oxygen consumption assessment. Participants walked on a treadmill at their self-selected, usual walking speed for up to

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