Community-Based Essentrics Training Program

By

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ABSTRACT

Healthy aging is associated with declines in functional performance and the ability to complete activities of daily living (ADLs) independently. Multicomponent exercise programs focused on the development of balance, flexibility, muscular fitness, and functional mobility contribute to maintenance of functional performance in healthy older adults. One such program is Essentrics, a low-impact group fitness program. The effects of Essentrics training on physical performance outcomes in community-dwelling older adults were investigated in these studies. Physical performance assessments included the Berg Balance Scale (BBS), Chair Sit and Reach (CSR), Back Scratch Test (BST), Short Physical Performance Battery (SPPB), Timed-Up-and-Go (TUG), and the 30-Second Chair Stand Test (30 CST).

The sample included 12 older adults (73 ± 6 years; 10 females, 2 males). Participants were recruited from fitness classes at a senior community center and had been engaged in different physical activities for at least 3 months, including programs focusing on aerobic endurance, muscular fitness, balance, and flexibility. Participants completed a pre-testing assessment prior to engaging in 8 weeks of Essentrics training. Post-testing assessments were conducted within one week after the end of the training intervention.

There were significant improvements in BBS, SPPB, TUG, and 30 CST scores. No significant improvement was observed in CSR or BST scores. Notably, participants demonstrated performance improvements greater than the minimum detectable change values for the SPPB and 30 CST, indicating meaningful improvements in functional

performance. However, high baseline levels of performance on the BBS and TUG led to smaller relative improvements in the ability to complete ADLs.

Overall, Essentrics was a safe and effective training program which yielded improvements in balance, muscular fitness, and functional mobility in community-dwelling older adults. When taught in a group fitness setting, Essentrics encouraged exercise adherence through social interaction, with an added benefit of safety monitoring by a qualified instructor. As a low-impact form of exercise, Essentrics may be a suitable option when designing multicomponent fitness programs for older adults.

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CHAPTER I

INTRODUCTION

Health care costs associated with healthy aging have increased as the population of individuals aged 65 years or older has continued to grow (Administration on Aging [AOA], 2020). Community-dwelling older adults comprise the majority of this population (AOA, 2020). Public health authorities emphasize the importance of preserving independence in performing activities of daily living (ADLs) to reduce the likelihood of admission to long-term care facilities among older adults, especially for individuals aged 75 years and older (AOA, 2020). Health care practitioners working with older adults consider fall risk of particular concern due to its prevalence and its potential to contribute to a loss of independence among community-dwelling older adults (American Geriatrics Society/British Geriatrics Society [AGS/BGS], 2011; Centers for Disease Control and Prevention [CDC], 2020). Fall risk prevalence is related to overall functional performance, which is affected by components of physical fitness such as balance, muscular fitness, and flexibility (Liguori et al., 2022). Gait speed is a predictor of adverse health outcomes, affecting functional mobility and fall risk prevalence (Bhasin et al., 2020).

Healthy aging typically involves physiological changes in health- and skill-related components of physical fitness (Liguori et al., 2022). Physiological changes in balance may include declines in vestibular, visual, and somatosensory systems leading to altered postural control (Alexander, 1994; Ivanenko & Gurfinkel, 2018). The ability to maintain static and dynamic balance declines with advancing age and is critical for performing ADLs (Alexander, 1994; Ivanenko & Gurfinkel, 2018). Research supports the use of balance training as part of an effective fall prevention plan for older adults (CDC, 2020; Liguori et al., 2022; United States Department of Health and Human Services [DHHS], 2018). Balance training programs may include functional exercises performed in a supervised group fitness setting (AGS/BGS, 2011; DHHS, 2018).

Declines in muscular strength and power are also associated with healthy aging (Billot et al., 2020; Liguori et al., 2022; Reid & Fielding, 2012; Tieland et al., 2018). Physiological changes in the structure and function of muscle, including reductions in muscle fiber count and size, as well as shifts in fiber type, may lead to the development of sarcopenia (Cruz-Jentoft et al., 2019; Tieland et al., 2018). Low muscle mass, strength, and power impair functional performance outcomes in older adults (Wang et al., 2020). Public health authorities recommend participation in multicomponent exercise programs to develop or maintain muscular fitness in older adults (DHHS, 2018). Interventions incorporating neuromuscular challenges for balance and coordination enhance the effectiveness of standard muscular strength and power training programs for older adults (DHHS, 2018; Liguori et al., 2022).

Flexibility is another health-related component of physical fitness recognized by public health authorities for its importance in preventing falls in older adults (AGS/BGS, 2011; DHHS, 2018). Range of motion (ROM) is joint-specific and may be affected by repetitive motions performed during certain ADLs (Stathokostas et al., 2013). Factors contributing to reduced ROM in older adults include changes in muscle and tendon elasticity, reduced tensile strength, increased joint stiffness, and decreased mobility

(Bonder & Dal Bello-Haas, 2018). Physical activity guidelines include performing static and dynamic flexibility exercises to maintain functional independence for older adults (DHHS, 2018).

Mobility impairments may lead to a loss of independence in performing ADLs for older adults (Campanelli, 1996; Daley & Spinks, 2000; Webber et al., 2010). Gait speed is assessed as a marker of physical performance to determine the effects of sarcopenia in limiting mobility (Cruz-Jentoft et al., 2018). Older adults exhibit alterations in gait pattern and speed compared to younger adults, including decreased stride length, differences in cadence, and decreased ROM in lower extremity joints (Chodzko-Zajko et al., 2009; Friere Júnior et al., 2016; McGibbon & Krebs, 2004). Slower gait speed is associated with declines in functional performance and increases in all-cause mortality risk (Bortone et al., 2021; Figgins et al., 2021; Guralnik et al., 2000; Studenski et al., 2011). As part of a multicomponent exercise program, the CDC (2022) recommends incorporating variations in walking (walking backward, standing on one leg, and using a wobble board) to challenge gait pattern abilities in older adults in an effort to improve coordination and balance.

Public health authorities recommend specific evidence-based exercise programs to maintain functional performance in older adults (CDC, 2020). Tai Chi: Moving for Better Balance (TCMBB) and Stay Active and Independent for Life (SAIL; AGS/BGS, 2011; DHHS, 2018; Shumway-Cook et al., 2007) are two evidence-based programs offered by senior community centers across the U.S. Tai Chi and SAIL include static and dynamic balance exercises taught in a group setting with professional instruction to ensure the safety of the older adult population (Cress et al., 2006; Li, 2014; Shumway-

Cook et al., 2007). Essentrics is an exercise program also incorporating elements of static and dynamic balance and can be performed individually or in a group setting (Esmonde-White, 2015). Essentrics movements use body weight for resistance and involve weight-shifts of the torso as the base of support alternates between a narrow and wide stance (Esmonde-White, 2015). Tai Chi, SAIL, and Essentrics use controlled, full-body movements to develop or maintain balance, strength, and flexibility in older adults (Esmonde-White, 2015; Li, 2014; Shumway-Cook et al., 2007). There is extensive research on the effectiveness of Tai Chi and SAIL for improving health-related components of fitness for older adults (Li, 2014; Shumway-Cook et al., 2007). While the effects of Essentrics on strength, flexibility, and body composition have been studied in younger adults (Zarco et al., 2022), research on the effects of the Essentrics training program on older adults is limited.

Overall Purpose

This dissertation includes two studies of an 8-week Essentrics training intervention with community-dwelling older adults. The purpose of the first study was to assess the effects of Essentrics on static and dynamic balance and flexibility, factors contributing to functional performance outcomes. It was hypothesized that Essentrics training would lead to improvements in each outcome measure for balance and flexibility from pre- to post-training. The second study was designed to assess the effects of Essentrics on several components of physical fitness through a series of multifactorial assessments. These components included balance, strength, and functional mobility, including usual gait speed. It was hypothesized that Essentrics would yield improvements in each of these components.

Significance of Studies

As the population of individuals aged 65 years and older continues to grow, health care costs associated with aging increase accordingly. Typical physiological changes related to healthy aging may lead to increased fall prevalence, declines in physical performance, and loss of independence for previously community-dwelling older adults. Research supports engaging in regular exercise to counteract age-related declines in health- and skill-related components of physical fitness. In addition to aerobic fitness, public health authorities recommend multicomponent exercise programs incorporating balance, strength training, and flexibility for older adults. Senior community centers offer evidence-based exercise programs supporting the physical and social well-being of older adults. If Essentrics is shown to be beneficial for improving balance, strength, flexibility, and functional mobility for older adults, this program could be a suitable addition to the multicomponent exercise interventions currently recommended by public health authorities.

CHAPTER II

LITERATURE REVIEW

This literature review begins with an overview of the demographics and health care costs of the aging population in the United States. A description of the physiological changes associated with aging follows, including the effects of healthy aging on health- and skill-related components of physical fitness, such as balance, muscular fitness, and flexibility. Age-related declines in usual gait speed as related to functional mobility are also explored. Next is an explanation of the physical performance assessments used to test each of the four components. Two evidence-based training programs are described, leading to the introduction of a novel protocol for developing or maintaining functional performance in older adults. The literature review concludes with a discussion of the Essentrics fitness training program, recognizing a gap in research in assessing the effectiveness of the program for maintaining functional performance in community-dwelling older adults.

Prevalence and Health Care Costs of Aging

The population of older adults continues to grow in the United States, with 41% of the "baby boom" population now aged 65 years or older (Administration on Aging [AOA], 2020). The Administration on Aging (2020) reports that in 2019, there were 54.1 million older adults in the United States comprising 16.1% of the population, representing a 36% increase since 2009. By 2040, there is projected to be 80.8 million older adults in the U.S., comprising 21.6% of the population, aged 65 years and older.

Most older adults in the United States are community-dwelling, with only 1.2 million (2%) living in long-term care facilities in 2019. The percentage of those who live in assisted living facilities increases with age, with 2% of individuals aged 75-84 years and 8% of individuals aged 85 and older living in long-term care facilities (AOA, 2020).

Medical management of the physiological changes associated with the aging population is costly. In 2019, older adults incurred average individual health care costs of $6,833, an increase of 41% over the last 10 years (AOA, 2020). In 2020, Medicare spending increased 3.5% from the prior year to $829.5 billion, representing 20% of total national health expenditures (NHE) in the U.S. (Centers for Medicare & Medicaid Services [CMMS], 2021). Between 2019-2028, NHE are projected to increase 5.4% annually, to reach $6.2 trillion by 2028. Medicare spending is projected to exceed the average growth rate of NHE, accounting for a 7.6% increase annually through 2028 (CMMS, 2021).

An aging-specific cost to consider is the increased occurrence of falls necessitating medical care. In 2015, national health expenditures directly attributable to falls was $49.5 billion, including $37.6 million paid by Medicare and Medicaid combined (Florence et al., 2018). Expenses related to falls included hospital stays, placement in long-term care facilities, home health services, and durable medical equipment (CMMS, 2021). These costs place additional burden on taxpayer-funded public health insurance programs already operating within considerable budgetary constraints.

Fall risk prevention is an important consideration in the older adult population for not only medical and care costs, but for maintenance of independence and quality of life. Falls and fall-related injuries cause older adults to limit regular activities for a period, although only 1/3 of older adults reported seeking medical treatment for injuries sustained during a fall (Moreland et al., 2020). Falling, however, is not uncommon. In 2018, 27.5% of all adults over age 65 years incurred a fall in the past year, while 33.8% of adults aged 85 or older reported a fall (Moreland et al., 2020).

Costs associated with fall risk prevalence and the associated loss of independence will continue to increase for individuals and governments as the older adult population grows (AOA, 2020; CMMS, 2021; Moreland et al., 2020). Interventions focusing on modifiable risk factors such as improving balance, increasing muscular strength, and maintaining flexibility over the lifespan may lead to the development or maintenance of healthy functional performance outcomes in older adults.

Balance and Aging

It is understood that physiological changes occur with healthy aging, including health-related changes that affect functional performance, which is the ability to perform activities of daily living (ADLs) safely and effectively (Bergen et al., 2019; Bonder & Dal Bello-Haas, 2018; Coll et al., 2020; Hsiao et al., 2020; Liguori et al., 2022; Lusardi et al., 2003; Manchester et al., 1989; Osoba et al., 2019; Wang et al., 2020; Yeung et al., 2019). Physiologic responses associated with chronological age vary widely among individuals (Liguori et al., 2022). In older adults, interventions to develop or maintain functional performance over the lifespan can result in improved quality of life (Bonder & Dal Bello-Haas, 2018). While many physiological mechanisms are impacted by aging, modifiable factors affecting functional performance include balance, muscular strength, flexibility, and gait speed (American Geriatrics Society, 2011; Bergen et al., 2019; Liguori et al., 2022; Lusardi et al., 2003).

Age-related physiological changes in balance

The physiological mechanisms associated with balance impairment in healthy aging involve altered postural control, the ability to maintain an upright posture over the body's base of support while standing (static balance) or moving (dynamic balance; Bonder & Del Bello-Haas, 2018). Maintaining upright posture requires controlling the body's center of mass within the limits of stability without changing the base of support (Alexander, 1994). Stability limits are set by measuring the degree of oscillation in the center of pressure (COP) when an individual stands on a force plate. Center of pressure is the central point of vertical reaction force within a base of support, typically in between the feet in a parallel, bipedal stance (Alexander, 1994; Osoba et al., 2019). During static posture and dynamic movements, COP constantly changes to keep the body in an upright position (Alexander, 1994; Ivanenko & Gurfinkel, 2018). The ability to maintain postural control for dynamic balance is essential for performance of most ADLs, and postural control responses are task-specific (Alexander, 1994; Ivanenko & Gurfinkel, 2018). Balance and postural control are regulated by sensorimotor feedback mechanisms that may decline in function throughout the lifespan (Alexander, 1994; Gabriel et al., 2021; Henry & Baudry, 2019; Hsiao et al., 2020; Manchester et al., 1989; Osoba et al., 2019; Wiesmeier et al., 2015).

Healthy aging involves changes in the vestibular, visual, and somatosensory systems that diminish the ability to maintain static or dynamic balance when an individual encounters an unexpected perturbance (Gabriel et al., 2021; Hsiao et al., 2020; Ivanenko & Gurfinkel, 2018; Manchester et al., 1989; Osoba et al., 2019). The vestibular system maintains equilibrium by detecting the rate and position of linear and angular movements of the head (Costanzo, 2022). The otolith organs (utricle and saccule) and semicircular canals coordinate with the retina to provide a stable visual field while the head is moving (Costanzo, 2022). This coordination allows the body to adjust posture to maintain balance. A reduced number of hair cells in the semicircular canals impairs the feedback mechanism needed to maintain postural control and balance (Allen et al., 2016; Rauch et al., 2001). Additionally, structural changes of the eye cause alterations in depth perception and peripheral vision, reducing visual function (Wiesmeier et al., 2015). Osoba et al. (2019) suggested the sensory decline associated with aging causes older adults to rely heavily on visual inputs to maintain static and dynamic balance, and reduced visual acuity further exacerbates postural instability.

Somatosensory changes that occur with healthy aging involve inhibited responses to mechanoreceptors that provide the proprioceptive input necessary for postural control (Henry & Baudry, 2019; Osoba et al., 2019; Wiesmeier et al., 2015). Wiesmeier et al. (2015) demonstrated that older adults rely most heavily on proprioceptive cues compared to vestibular or visual inputs when stabilizing the body across various support surfaces. Larger disturbances such as standing on a compliant surface (a foam pad) or narrowing the base of support require greater adaptations of somatosensory inputs to avoid a high degree of postural sway (Alexander, 1994; Hsiao et al., 2020; Wiesmeier et al., 2015).

To reduce postural sway, older adults respond differently to external perturbations while standing compared to younger adults (Alexander, 1994; Henry & Baudry, 2019; Manchester et al., 1989; Osoba et al., 2019; Wiesmeier et al., 2015). When standing, younger adults exhibit a distal to proximal muscle sequencing pattern (Manchester et al., 1989). When anterior perturbations induce posterior sway, muscle recruitment initiates with the tibialis anterior, then the quadriceps, and finally the abdominal muscles (Manchester et al., 1989). When posterior perturbations induce anterior sway, muscle recruitment initiates with the gastrocnemius, then the biceps femoris, and finally the paraspinal muscles (Manchester et al., 1989). Older adults exhibit a proximal to distal muscle sequencing pattern, activate antagonist muscles, and rely on hip flexion or extension to a greater degree than younger adults to maintain static balance (Manchester et al., 1989; Osoba et al., 2019).

Other factors may contribute to balance declines in older adults. Comorbidities such as orthostatic hypotension or poor sensation in the feet due to diabetic neuropathy may inhibit one's ability to maintain balance with advancing age (AGS/BGS, 2011; National Center for Injury Prevention and Control, 2020). Increased medication use to manage the signs and symptoms of chronic disease may also adversely impact balance. Mental health considerations such as low cognition or high distractibility can lead to a higher prevalence of falls (AGS/BGS, 2011; National Center for Injury Prevention and Control, 2020). As an individual experiences an increased number of fall events, poor self-efficacy and increased fear of falling lead to reduced physical activity (AGS/BGS, 2011; Gerards et al., 2021). A reduction in physical activity may lead to a loss of functional performance, contributing to static and dynamic instability and declines in other health-related variables such as muscular strength and flexibility (AGS/BGS, 2011; Gerards et al., 2021; Liguori et al., 2022).

Muscular Fitness and Aging

Components of muscular fitness, including muscle strength and power, are affected by the aging process (Billot et al., 2020; Liguori et al., 2022; Reid & Fielding, 2012; Tieland et al., 2018). Muscle strength is the maximal force produced by a muscle or muscle group (Liguori et al., 2022) whereas muscle power is the rate that work is performed, the force of a muscle contraction multiplied by its velocity (Billot et al., 2020; Chodzko-Zajko et al., 2009; Liguori et al., 2022). Beginning in middle age (40–50 years), concentric, eccentric, and isometric strength begin to decline, and the decline accelerates after age 65 years (Chodzko-Zajko et al., 2009; Coll et al., 2020). Additionally, lower body strength declines faster than upper body strength (Chodzko-Zajko et al., 2009). Muscle power declines earlier and more rapidly than strength with increasing age (Billot et al., 2020; Chodzko-Zajko et al., 2009; Foldvari et al., 2000; Liguori et al., 2022; Reid & Fielding, 2012). This is important to note, as Foldvari et al. (2000) found peak muscle power in the lower extremities was superior to muscle strength as a predictor of functional performance. Bean et al. (2002) reported that leg power predicted 15–50% of the variance in performance of usual gait speed and chair-stand time in older adults. Also, training interventions focusing on muscle power are associated with increased satisfaction with physical function and improved quality of life compared to interventions for muscle strength in older adults (Katula et al., 2008). Based on the importance of power as a predictor of functional performance, the American College of Sports Medicine (ACSM) now recommends including a measurement of muscle power in fitness assessments of older adults (Liguori et al., 2022).

Age-related physiological changes in skeletal muscle

Changes in skeletal muscle structure and function occur with healthy aging (Billot et al., 2020; Cruz-Jentoft et al., 2019; Liguori et al., 2022; Miljkovic et al., 2015; Reid & Fielding, 2012; Tieland et al., 2018; Trombetti et al., 2016; Wang et al., 2020). Aging is a primary risk factor for the development of sarcopenia (Bhasin et al., 2020; Billot et al., 2020; Cruz-Jentoft et al., 2019; Tieland et al., 2018). The Writing Group for the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) defined sarcopenia as a skeletal muscle disorder characterized by low muscle strength, leading to low physical performance and an increased likelihood of falls and associated disability (Cruz-Jentoft et al., 2019). The Sarcopenia Definition and Outcomes Consortium (SDOC) expanded the definition to include slow gait speed as an indicator of sarcopenia and a predictor of adverse health outcomes (Bhasin et al., 2020).

People who are aging experience a loss in the number of muscle fibers and a decrease in the size of remaining muscle fibers, contributing to declines in muscle strength and power (Gustafsson & Ulfhake, 2021; Tieland et al., 2018). The number of motor units also declines with age so each motor neuron must innervate a greater number of fibers per unit, resulting in less effective muscle fiber recruitment (Gustafsson & Ulfhake, 2021; Tieland et al., 2018). Confounding the loss of muscle fiber number and size is an increase in adipose and thickening of connective tissue in skeletal muscle, reducing the muscle's ability to generate force (Miljkovic et al., 2015; Tieland et al., 2018; Trombetti et al., 2016; Wang et al., 2020).

Aging is also associated with shifts in muscle fiber type from Type II fibers to Type I fibers (Chodzko-Zajko et al., 2009; Liguori et al., 2018; Miljkovic et al., 2015; Tieland et al., 2018). Type II fast twitch muscle fibers decrease in number and size (Chodzko-Zajko et al., 2009; Liguori et al., 2018; Tieland et al., 2018). The loss reduces muscle power in older adults (Chodzko-Zajko et al., 2009; Tieland et al., 2018).

Conversely, Type I (slow twitch) muscle fibers remain relatively unaffected by the aging process (Miljkovic et al., 2015).

Maintenance of muscular fitness and functional performance with age

Maintenance of muscular fitness is an important component to healthy aging to preserve functional performance. Specifically, the ACSM indicates deficits in muscle strength and power are predictors of disability and mortality risk in older adults (Chodzko-Zajko et al., 2009). Trombetti et al. (2016) stated low muscle mass and low physical performance were associated with reduced quality of life, and low muscle strength was associated with increased fear of falling. Further, Wang et al. (2020) found low muscle mass, strength, and power were predictors of impaired performance of ADLs.

Fortunately, the negative impact of sarcopenia on functional performance is potentially modifiable (Cruz-Jentoft et al., 2019; Trombetti et al., 2016). Generally, recommendations center on a multicomponent approach when aiming to maintain function with age. The American Geriatrics Society (2011) recommends community-dwelling older adults participate in a structured exercise program as one component of a multifactorial approach to fall prevention. Marzetti et al. (2017) suggested combining different types of exercise was more effective in improving muscular strength and functional performance than a single exercise program. The AGS/BGS (2011) recommends exercise interventions that encompass balance, gait, and strength training for older adults at risk of falling. Also, the 2018 Physical Activity Guidelines for Americans (Guidelines) include recommendations for performing multicomponent physical activities to improve functional performance, including any combination of balance, muscle strengthening, aerobic, gait, and coordination activities conducted in a community setting (U.S. Department of Health & Human Services [DHHS], 2018).

Within the 2018 Guidelines it is recommended adults perform muscle-strengthening activities involving all major muscle groups on two or more days per week (DHHS, 2018). More specifically, the ACSM recommends older adults implement a progressive weight training program that includes strengthening activities such as resistance training and weight-bearing calisthenics for all major muscle groups (Liguori et al., 2022). The programming recommendation is 8-10 exercises, performing 1-3 sets of 10-15 repetitions for beginners and progressing to 8-12 repetitions per set with gradually increasing resistance (Liguori et al., 2022). For increasing muscle power, the ACSM recommends that older adults perform single joint and multiple joint exercises using light-to-moderate loads at high velocity for 6-10 repetitions (Liguori et al., 2022).

While there is abundant evidence of the decline in muscular strength and power with age and existing guidelines to minimize these changes, the decline in functional performance and the risk of falling with age remain concerns. Based on National Health Interview Survey data from the Centers for Disease Control and Prevention (CDC), the Federal Interagency Forum on Aging-Related Statistics reported that in 2014, only 17% of older adults met the Guidelines for muscle-strengthening activities (Federal Interagency Forum on Aging-Related Statistics, 2016). Therefore, there remains a need for targeted interventions to increase the number of older adults who participate in programs to improve or maintain muscular fitness.

Flexibility and Aging

Flexibility, the ability to move a joint through a complete range of motion, is recognized by public health authorities as a third component in preventing falls and improving functional performance in older adults (AGS/BGS, 2011; DHHS, 2018; NCIPC, 2020). The 2018 Physical Activity Guidelines for Americans suggest older adults should maintain sufficient flexibility to engage in regular physical activity and to perform ADLs (DHHS, 2018; Liguori et al., 2022).

Range of motion (ROM) is joint-specific and can be influenced by muscle viscosity and the compliance of surrounding ligaments and tendons (Chodzko-Zajko et al., 2009; Liguori et al., 2022). The specificity of joint ROM is attributed to the chronic use of each joint, such as the repetitive motion involved in performing ADLs (Stathokostas et al., 2013). Chodzko-Zajko et al. (2009) reported significant declines in ROM for specific joints in adults aged 70 years and older: hip and spine ROM declined by 20-30%, and ankle flexion was reduced by 30-40%. Decreased ROM at the hip, knee, and ankle joints affected walking patterns and activities requiring bending and reaching movements (Christiansen, 2008; Spiriduso et al., 2005; Stathokostas et al., 2013). Decreased ROM at the shoulder and elbow joints affected the ability of older adults to perform ADLs requiring overhead reaching movements, inhibiting independence in completing personal hygiene or home maintenance tasks (Oosterwijk et al., 2018).

There are several factors that begin to limit flexibility with age. One factor is decreased muscle and tendon elasticity compared to younger adults (Chodzko-Zajko et al., 2009). Changes in the amount and density of collagen and elastin in connective tissues lead to decreased tensile strength, increased joint stiffness, and decreased mobility

(Bonder & Dal Bello-Haas, 2018). Decreased hydration in vertebral discs causes inflexibility in the spine, affecting postural stability and functional performance (Bonder & Dal Bello-Haas, 2018; Daley & Spinks, 2000; Galbusara et al., 2014). Decreased flexibility may lead to development of lower back pain and increased risk of falling (Chodzko-Zajko et al., 2009). Collectively, these changes require a need to focus on maintaining flexibility through the lifespan.

Recommendations to maintain flexibility

It is recommended flexibility exercises be included as part of a multifactorial intervention program to prevent falls and optimize functional performance in older adults (AGS/BGS, 2011; DHHS, 2018; Liguori et al., 2022). Oosterwijk et al. (2018) suggested maintaining the minimal ROM required for task-specific performance of ADLs should be a treatment goal in rehabilitation settings. Additionally, community-based or home-based multicomponent exercise programs incorporating balance, strength, and flexibility exercises are recommended to maintain independence in performing ADLs and improving quality of life in older adults (DHHS, 2018).

There are many benefits derived from regular stretching. Pfeifer et al. (2022) found engaging in stretching exercises reduced the likelihood of developing functional limitation in older adults. Static stretching to increase hip extension and ankle dorsiflexion was associated with improvements in usual gait speed, necessary in performing task-specific ADLs such as crossing the street safely (Christiansen, 2008). Bird et al. (2009) suggested targeted flexibility training programs were useful to improve measures of postural stability and balance, potentially reducing fall risk in older adults.

When incorporating stretching exercise, the ACSM recommends older adults engage in flexibility exercises two or more days per week, performing slow movements ending in static stretches. Static stretches should be held to the point of tightness or slight discomfort for 30-60 s. In addition to static stretching, benefits can also be derived from dynamic movements. Dynamic stretching involves slow, repetitive movement with progressively increasing ROM through a gradual transition between different body positions (Liguori et al., 2022). Dynamic stretches are effective to prepare the body for physical activity, likely resulting from acute decreases in muscle and tendon stiffness and from improvements in neuromuscular conduction and compliance (Behm et al., 2016; Liguori et al., 2022). The ACSM recommends older adults perform dynamic flexibility exercises prior to engaging in moderate to vigorous exercise (Liguori et al, 2022).

Functional Mobility and Aging

Maintenance of mobility, the ability to move independently in one's home and community, is essential to preserve functional performance in older adults (Bonder & Del Bello-Haas, 2018; Campanelli, 1996; Daley & Spinks, 2000; Webber et al., 2010). Gait speed is a sensitive test for identifying mobility impairments and is a strong predictor of fall risk in older adults (Bonder & Del Bello-Haas, 2018; Guralnik et al., 2000; Middleton et al., 2015; Ruggero et al., 2013). Gait speed is also assessed as a marker of physical performance in the EWGSOP2 definition of sarcopenia (Cruz-Jentoft et al., 2018). Maintenance of sufficient gait speed is necessary to perform ADLs such as walking the dog or catching a bus (Freiberger et al., 2020).

Older adults exhibit altered gait patterns and gait speed compared to younger adults (Bonder & Del Bello-Haas, 2018; Fiser et al., 2010). Typical changes include decreased stride length, altered cadence, and decreased ROM in the hip, knee, and ankle joints (Bonder & Del Bello-Haas, 2018; Chodzko-Zajko et al., 2009; Freire Júnior et al., 2016; McGibbon & Krebs, 2004). Older adults demonstrate reduced hip extension and knee flexion, reducing ankle power at push-off (McGibbon, 2003). At the ankle joint, older adults demonstrate reduced plantarflexion, deficits in torque production, and reduced mitochondrial activity in plantar flexor muscles compared to younger adults (DeVita & Hortobagyi, 2000; McGibbon & Krebs, 2004). Differences in biomechanical and physiological function of the plantar flexors contribute to a longer relative stance time in older adults (DeVita & Hortobagyi, 2000). Longer stance time increases stability when walking, as it increases the amount of time both feet remain in contact with the floor (DeVita & Hortobagiy, 2000). Despite longer stance time, older adults exhibit faster cadence to compensate for reduced stride length when walking at usual gait speed (DeVita & Hortobagiy, 2000). Older adults also exhibit hip and knee extensor torques and plantar flexor torques of 74, 13, and 12% compared to torques of 37, 35, and 28%, respectively, in younger adults (DeVita & Hortobagyi, 2000). Increased hip extension results in higher mechanical work expenditure during the stance phase for older adults (DeVita & Hortobagiy, 2000; Jerome et al., 2015). Additionally, increased relative contribution from hip extensor muscles to stabilize the trunk was found to compensate for reduced ankle plantarflexion when advancing the leg into swing phase (McGibbon, 2003).

Lower levels of self-reported physical activity also contribute to slower gait speed in older adults (Chodzko-Zajko et al., 2009; Figgins et al., 2021; Ruggero et al., 2013). Maximal volume of oxygen consumed per unit of time (VO_{2max}) is a strong predictor of mobility (Fiser et al., 2010). Maximal volume of oxygen declines approximately 10% per decade from age 20 to 60 years, and declines 15-20% for each decade over 60, although loss rates are non-linear due to reduced muscle mass and mitochondrial dysfunction (Fiser et al., 2010; Hawkins & Wiswell, 2003; Short et al., 2005). Age-related declines in VO_{2max} are associated with decreased levels of physical activity and slower usual gait speed (Fiser et al., 2010; Hawkins & Wiswell, 2003). As VO_{2max} declines with increasing age, the oxygen cost of maintaining usual gait speed increases, inducing fatigue and slowing gait speed in older adults (Fiser et al., 2010).

Slower gait speed is associated with declines in functional performance (Bonder & Del Bello-Haas, 2018; Bortone et al., 2021; Figgins et al., 2021; Paulson & Gray, 2015). Cut points for gait speed are established in reference to usual gait speed, an individual's preferred, comfortable walking pace (Abellan Van Kan et al., 2009; Cesari et al., 2005). A usual gait speed slower than 1 m/s indicates progressive declines in health-related outcomes, including increased risk of falls, hospitalization, and death (Bonder & Del Bello-Haas, 2018; Cesari et al., 2005; Fritz & Lusardi, 2009; Middleton et al., 2015; Ruggero et al., 2013). A change of 0.10 m/s in gait speed is considered substantial, with significant increases in mortality risk associated with each 0.10 m/s increment in slower gait speed (Guralnik et al., 2000; Studenski et al., 2011).

Recommendations to maintain functional mobility

Engaging in structured exercise is recommended for older adults while implementing any necessary accommodations for mobility limitations (AGS/BGS, 2011; CDC, 2020; DHHS, 2018). Interventions focused on maintenance of functional mobility and gait-related performance of ADLs should include balance and coordination exercises in addition to aerobic and muscle strengthening activities (Bonder & Del Bello-Haas, 2018; CDC, 2022; DHHS, 2018; Liguori et al., 2022). The CDC recommends incorporating variations in walking, such as walking backward, standing on one leg, and using a wobble board to maintain balance and healthy gait patterns (CDC, 2022). Activities requiring different types of movement, including yoga, Tai Chi, gardening, dancing, or sports are recommended as multicomponent exercises to improve or maintain functional performance in older adults (CDC, 2022).

Physical Performance Assessments

Balance assessment

Maintaining balance is necessary to perform most ADLs (Bonder & Dal Bello-Haas, 2018). In older adults, balance is one component of multifactorial fall prevention programs (AGS/BGS, 2011; CDC, 2020; Chodzko-Zajko, 2009; Liguori et al., 2022; Lima et al., 2018; Shumway-Cook et al., 1997). Clinical assessments of balance evaluate static and dynamic balance, and proactive and reactive postural control (Bonder & Dal Bello-Haas, 2018). Proactive, or anticipatory balance, involves self-initiated postural control and locomotion responses to avoid a potential hazard (Woollacott & Tang, 1997). Reactive postural control mechanisms are activated in response to an unexpected perturbance (Woollacott & Tang, 1997). Laboratory assessments of balance typically include the use of a force plate to measure postural sway while standing quietly or during movement (Bonder & Dal Bello-Haas, 2018). While force plate technology provides information on static and dynamic balance for clinicians, it is important to assess older adults while performing functional balance tasks that simulate everyday activities (Bonder & Dal Bello-Haas, 2018; Lima et al., 2018).

The Berg Balance Scale (BBS) is a valid and reliable assessment of functional balance in older adults (Berg et al., 1992a; Lima et al., 2018; Muir et al., 2008). Participants are evaluated on the ability to perform 14 tasks requiring static, dynamic, and proactive balance without external support (Berg et al., 1989; Berg et al., 1992a; Soubra et al., 2019). Static balance tasks involve changing the base of support from positions of high stability to more challenging positions, from standing with feet parallel with eyes opened and with eyes closed, to standing in tandem stance, to standing on one leg. Dynamic balance tasks include chair rises and transfers, a functional reach test, and trunk rotations. Proactive balance is required to maintain postural control while performing most tasks, from sit-to-stand transitions to retrieving an object off the floor (Berg et al., 1989; Berg et al., 1992a).

The score for each item on the BBS ranges from 0 to 4, with 0 indicating the participant is unable to complete the task and 4 indicating the task is performed independently without external assistance, including using one's arms to push off the armrests during chair rises (Berg et al., 1992a). The maximum score is 56, with higher scores indicating better performance (Soubra et al., 2019). Research is equivocal regarding the accuracy of cut points in the BBS for purposes of evaluating fall risk in older adults (Lima et al., 2018). Berg et al. (1992a) suggested an initial cutoff score of 45 to identify individuals at risk of falling. Muir et al. (2008) reported cutoff values for any fall, multiple falls, and injurious falls of 54, 53, and 54, respectively, indicating that fall risk begins at cutoff points well above 45. Lima et al. (2018) suggested a cutoff score of ≤ 50 for any fall within a 12-month period. Shumway-Cook et al. (1997) reported using the original cutoff score of 45 on the BBS had moderate sensitivity of 64%. The instrument has high specificity at 90%, indicating the BBS is valuable for identifying people who are not at risk of falling (Shumway-Cook et al., 1997).

The BBS may be subject to floor and ceiling effects (Donoghue et al., 2009). A higher minimum detectable change (MDC) value was required for individuals needing more assistance to complete functional tasks (Donoghue et al., 2009). Minimum detectable change values were reported for scores of 45-56: 3.3 points, 35-44: 4.9 points, and 25-34: 6.3 points (Donoghue et al., 2009). Donoghue et al. (2009) suggested the floor effect may be due to difficulty in recruiting participants with BBS scores of 0 to 24 in a community setting. Shumway-Cook et al. (1997) reported possible ceiling effects. At the high end of scores ranging from 54 to 56, a 1-point decrease was associated with a 3% to 4% increase in fall risk. In the mid-range of scores from 46 to 54, a 1-point decrease was associated with a 6% to 8% increase in fall risk, while very low scores (36 or below) were associated with nearly 100% fall risk (Shumway-Cook et al., 1997).

The BBS offers advantages for working with older adults in a community setting, as it is easy to administer with minimal time and equipment required (Soubra et al., 2019). The BBS has high intra- (ICC = 0.98) and inter-rater reliability (ICC = 0.98; Berg et al., 1992b). The BBS is a strong predictor to identify individuals at risk of multiple falls (Muir et al., 2008). While the BBS is not sufficient to accurately predict falls as a single measure (Lima et al., 2018), the functional nature of tasks is useful to assess performance of ADLs in a community setting (Bonder & Dal Bello-Haas, 2018; Steffen et al., 2002). Criterion-related validity of the BBS is demonstrated through moderate correlation of BBS scores with another functional performance assessment, the Timed-Up-and-Go (TUG) Test (Pearson $r = -.76$, n = 31; Steffen et al., 2002). As a valid measurement of static, dynamic, and proactive balance, the BBS is a valuable component of a multifactorial approach to assess functional performance and fall risk in older adults (Muir et al., 2008; Shumway-Cook et al., 1997; Steffen et al., 2002).

Muscular fitness assessments

Physical performance testing is an established mechanism for assessing functional status in older adults (Beaudart et al., 2019; Cesari et al., 2009; Guralnik et al., 2003; Liguori et al., 2022; MacRae et al., 1992). Functional performance measures are useful in predicting fall risk, disability, hospitalization, and death in older adults (Beaudart et al., 2019; Cesari et al., 2009; Guralnik et al., 2003). Physical performance tests of functional status are convenient to implement in a community setting, requiring minimal equipment, space, and cost (Beaudart et al., 2019; Liguori et al., 2022). One component of physical performance testing is the assessment of muscular fitness. Assessing muscular fitness is important in older adults because muscle weakness inhibits one's ability to perform ADLs independently (Beaudart et al., 2019). Lower extremity muscle strength and power are required for walking, climbing stairs, and rising from a chair, tub, or car (Beaudart et al., 2019; Bonder & Dal Bello-Haas, 2018; McCarthy et al., 2004; Rikli & Jones, 1999). The CDC recommends evaluation of lower extremity strength to identify older adults at risk of falling (CDC, 2020). As muscle power declines at a faster rate than muscle strength in older adults, physical performance tests simulating functional movements are useful to assess both components of muscular fitness (Bonder & Dal Bello-Haas, 2018; Liguori et al., 2022).

Isokinetic testing is commonly used in clinical settings to assess lower extremity muscle strength (Bonder & Dal Bello-Haas, 2018; McCarthy et al., 2004). While isokinetic testing measures absolute strength, it is not feasible in a community setting due to cost and equipment constraints (Beaudart et al., 2019; Kisner et al., 2018; McCarthy et al., 2004). Functional performance testing using sit-to-stand transitions is a suitable proxy for assessing lower extremity strength in older adults (Bonder & Dal Bello-Haas, 2018; Cruz-Jentoft et al., 2019; McCarthy et al., 2004). Performance of sit-to-stand transitions is necessary for many ADLs, including the initiation of walking (McCarthy et al., 2004). Functional performance tests that include sit-to-stand transitions such as the 30-Second Chair Stand (30 CST; Rikli & Jones, 1999), five-time sit-to-stand (5TSTS) and the Short Physical Performance Battery (SPPB) are useful for evaluating muscle strength and power in older adults (Beaudart et al., 2019; Yee et al., 2021).

Chair stand tests. The 5TSTS and the 30 CST tests begin with the participant seated in a chair with feet placed flat on the floor and arms folded across the chest (Rikli & Jones, 1999; Yee et al., 2021). Participants are asked to rise to a standing position with legs fully extended. The 5TSTS measures the time required for participants to complete five sit-to-stand transitions (Yee et al., 2021). The 30 CST measures the number of sit-to-stand transitions participants are able to complete in 30 s (Rikli & Jones, 1999).

Beaudart et al. (2019) reported time-based protocols such as the 30 CST are useful for assessing older adults with wide variations in functional performance abilities. The 5TSTS is useful to predict fall risk in older adults but is subject to a floor effect – participants unable to complete five sit-to-stand transitions are assigned a score of 0 (Beaudart et al., 2019; Yee et al., 2021). The 30 CST accounts for older adults with mobility limitations, as participants perform as many sit-to-stand transitions as possible in 30 s (Beaudart et al., 2019; Rikli & Jones, 1999). Participants perform only the number of transitions of which they are capable and are evaluated based on repetitions completed within the timeframe, instead of the ability to complete five full sit-to-stand cycles (Beaudart et al., 2019). Despite these limitations, both tests are widely used in community settings due to convenience and low cost (Yee et al., 2021). Both tests are also validated with high test-retest and inter-rater reliability (Applebaum et al., 2017; Makizako et al., 2017). Test-retest reliability of the 30 CST is 0.84 for men and 0.92 for women (Rikli & Jones, 1999). Makizako et al. (2017) reported cutoff values for the 5TSTS to predict the risk of developing disability in community-dwelling older adults. Older adults taking longer than 10 s to perform the 5TSTS and longer than 9 s to perform the TUG test have a three-times higher risk of developing future disability compared to older adults with shorter task completion times (Makizako et al., 2017). The Asian Working Group for Sarcopenia reported performance times of longer than 12 s on the 5TSTS were associated with the presence of sarcopenia in older adults (Chen et al., 2020).

Short physical performance battery. Performance of sit-to-stand tests is influenced not only by muscle strength and power, but also requires sufficient dynamic balance to complete each task successfully (McCarthy et al., 2004; Yee et al., 2021). High correlation between performance on the sit-to-stand tests and performance of other physical function tests such as the TUG and SPPB support the adoption of a multicomponent approach for exercise testing and prescription (Applebaum et al., 2017; Beaudart et al., 2019; Yee et al., 2021). Perracini et al. (2020) compared one component of the SPPB, the 5TSTS, with the entire SPPB test battery. As a single component, the 5TSTS was a good predictor of declines in functional performance in older adults, with a score of ≤ 1 indicating impairment of lower extremity muscle strength (Perracini et al., 2020). However, the total SPPB score was a better predictor of functional performance declines compared to any single component of the SPPB (Perracini et al., 2020).

The SPPB is a reliable and valid measure of functional performance in healthy older adults (Beauchamp et al., 2014; Kameniar et al., 2022). The SPPB assesses balance, usual gait speed, and lower extremity strength in individuals aged 60 years or over (Beaudart et al., 2019; Guralnik et al., 1994; Pavasini et al., 2016; Perracini et al., 2020; Ronai & Gallo, 2019). The 12-point total score is comprised of three subdomains: a three-stage balance test, two gait speed tests, and two chair stand tests (Ronai & Gallo, 2019). For the three-stage balance test, participants stand with varying bases of support, from feet parallel, to a semitandem stance, to a tandem stance. The gait speed test consists of two trials in which participants walk at their usual gait speed for 4 m, with the best time of the two trials recorded for a score. The chair stand tests begin with a single chair stand, in which participants are asked to rise from a chair with arms folded across the chest. The repeated chair stand test is the 5TSTS, in which participants are asked to rise from a chair five times without stopping in between each sit-to-stand transition (Ronai & Gallo, 2019).

Since functional performance assessments are frequently used with older adults, researchers must establish measures for detecting meaningful change (Kwon et al., 2009). Perera et al. (2014) reported the utility of the SPPB for detecting incremental changes in physical function over time. Substantial change is defined as a 1.0-point difference for healthy older adults (Kwon et al., 2009; Perera et al., 2014). A score of 10 or greater out of 12 points is associated with sufficient levels of balance, lower extremity strength, and mobility to perform ADLs independently (Guralnik et al., 1994; Ronai & Gallo, 2019). A range of 0.5-1.3 points was suggested for detecting meaningful change, although scores on the SPPB are recorded in whole units only (Kwon et al., 2009). A 1-point score decrease below 10 indicates substantial decline in lower extremity function and is associated with higher rates of disability and all-cause mortality (Guralnik et al., 1995; Pavasini et al., 2016). Individuals with scores of 7-9 were 1.6 to 1.8 times more likely to become disabled within four years of assessment compared to individuals with scores of 10 or greater (Guralnik et al., 1995). Individuals with scores of 4-6 were 4.2 to 4.9 times more likely to become disabled compared to the highest scoring group (Guralnik et al., 1995). Although the minimum detectable change of 1.0 is debated for declines in functional performance (Kameniar et al., 2022), the SPPB was most responsive to improvements in performance compared to other tests of lower extremity function (Beauchamp et al., 2014).

The 30 CST and 5TSTS are components of the Senior Fitness Test (SFT) and Short Physical Performance Battery respectively (Guralnik et al., 1994; Rikli & Jones, 1999). Both the SFT and the SPPB involve multicomponent assessments of balance, muscle strength and power, and usual gait speed (Guralnik et al., 1994; Rikli & Jones, 1999). The ACSM recommends either the SFT or the SPPB for evaluating functional performance in older adults (Liguori et al., 2022).

Flexibility assessments

Decreased flexibility may increase the risk of falls and injury in older adults (Chodzko-Zajko et al., 2009). Flexibility, in addition to muscular fitness and aerobic capacity, is important for mitigating mobility impairments in older adults (Glei et al., 2019). Decreased flexibility in the hamstrings is associated with dynamic balance impairments and gait limitations, including shorter stride length and slower usual walking speed (Jones et al., 1998). The ACSM recommends including flexibility in exercise testing and prescription protocols for older adults (Liguori et al., 2022).

Lower extremity flexibility assessment. An established measurement of hamstring flexibility for adults over 60 is the sit-and-reach test (Osness et al., 1990). The original sit-and-reach test requires participants to sit down on the floor, extend both legs, and stand up (Osness et al., 1990). Citing safety concerns, Rikli and Jones (1999) modified the original sit-and-reach test for older adults. Due to underlying conditions such as reduced lower extremity strength, lower back pain, or hip or knee replacements, older adults may find it difficult to sit down and stand up from the floor (Rikli & Jones, 1999). Older adults may also exhibit weakness in the abdominal muscles or limited hamstring flexibility, making it difficult to hold a sitting position with both legs extended, and may even fall backward during testing (Rikli & Jones, 1999). Rikli and Jones (1999) developed the Chair Sit-and-Reach Test (CSR) to decrease the risk of injury and increase participation rates for testing older adults.

The CSR involves stretching one hamstring instead of both, resulting in less stress placed on the lower back (Jones & Rikli, 1998). The participant begins by sitting near the front of a chair with one leg extended in front of the hip and the ankle dorsiflexed, and the other leg bent with the foot planted on the floor (Jones & Rikli, 1998). The participant is asked to lean forward, reaching one hand down the extended leg as far as possible, holding the position for 2 s, and returning to an upright sitting position (Jones & Rikli, 1998). The administrator holds a ruler parallel to the participant's extended leg and measures the distance between the participant's outstretched fingers and toes. If the participant is unable to reach the toes, a minus score is recorded in inches, and if the participant reaches past the toes, a plus score is recorded (Jones & Rikli, 2002). The risk zone for identifying mobility impairments is a minus score of 4 in. or more for men and 2 in. or more for women (Jones & Rikli, 2002).

The CSR has a strong correlation with goniometer measures of hamstring flexibility for men (.76) and women (.81) in 65-80 year old people, indicating good criterion-related validity (Jones & Rikli, 1998). Chair Sit-and-Reach scores were significantly higher in participants identified as exercisers compared to non-exercisers (Rikli & Jones, 1999). The CSR has good test-retest reliability (ICC = 0.95; Jones & Rikli, 1998). Jones and Rikli (1998) indicated the CSR is highly reliable and moderately valid for healthy older adults without orthopedic limitations. The safety and convenience of the CSR support its use in testing lower extremity flexibility in community-dwelling older adults (Jones & Rikli, 1998).

Upper extremity flexibility assessment. Upper extremity flexibility is necessary for completing many ADLs (Rikli & Jones, 1999). Shoulder flexibility is required for overhead reaching movements such as dressing or combing one's hair (Rikli & Jones, 1999). Apley's scratch test is an established measure of upper extremity flexibility (Kendall et al., 2005). The test measures ROM through shoulder abduction and adduction, and shoulder internal and external rotation by measuring the overlap or the distance between the middle finger of each hand held behind the back (Rikli & Jones, 1999). While Apley's scratch test involves reaching toward a specific anatomical point on the opposite scapula with the overhead arm, the test was modified to make touching the fingertips the primary goal (Rikli & Jones, 1999).

The back-scratch test begins with the participant reaching both arms behind the back, with the preferred arm reaching overhead and the other arm reaching up the middle of the back (Jones & Rikli, 2002). The administrator measures the degree of overlap as a plus score in inches, or the distance between the extended middle finger of each hand as a minus score (Jones & Rikli, 2002). The risk zone for reduced shoulder mobility is minus 4 in. or more for men and minus 2 in. or more for women (Jones & Rikli, 2002).

Although there is no single criterion measure for the back-scratch test, Rikli and Jones (1998) reported it is a valid measure of shoulder ROM. The back-scratch test is one component of the Senior Fitness Test, included in the ACSM's recommendations for assessing physical performance in older adults (Liguori et al., 2022). An assessment of upper and lower extremities is recommended to monitor for potential mobility impairments over time (Rikli & Jones, 1999).

Gait assessment. Functional mobility skills require coordination of dynamic balance and gait abilities (Woollacott & Tang, 1997). Assessments of functional status may include subjective measurements collected through questionnaires or objective measurements recorded in a laboratory or clinical setting (Podsiadlo & Richardson, 1991). Questionnaires may provide useful information to assess functional status in older adults, but results rely on self-reported information that may be influenced by language, hearing, or cognition (Podsiadlo & Richardson, 1991). Objective measurements assess functional performance by evaluating the ability to complete tasks commonly required for everyday activities and may be timed or untimed (Podsiadlo & Richardson, 1991).

Getting in and out of bed and walking a short distance without external assistance are important tasks for maintaining independence in older adults (Podsiadlo & Richardson, 1991). Walking is the primary daily activity in which missteps and trips pose the greatest fall risk to older adults (Woollacott & Tang, 1997). The CDC and AGS/BGS recommend the TUG test as a screening tool to identify fall risk in older adults (AGS/BGS, 2011; CDC, 2020). The TUG is an objective assessment of balance and gait maneuvers used in everyday activities (Podsiadlo & Richardson, 1991).

The TUG is administered as a single test with a practice trial to familiarize participants with the procedure (Beaudart et al., 2019). Participants begin by sitting in a chair with feet flat on the floor. Participants are asked to rise from the chair, walk 3 m at their usual, comfortable pace, turn around, return to the chair, and sit down again (Beaudart et al., 2019). Participants wear their usual footwear and may use an assistive device if they normally use one to ambulate. The only equipment required is a chair with armrests and tape to mark the distance on the floor. The test administrator uses a stopwatch to measure the time between the participant rising from the chair and sitting back down. Total time to complete the assessment is approximately 3 min (Beaudart et al., 2019).

The TUG has established cutoff points that are moderately correlated with the BBS ($r = -.72$; Podsiadlo & Richardson, 1991). Older adults performing the TUG in 20 s or less scored in the upper 1/3 tier of the BBS (scores 41-56), associated with independent performance of ADLs (Podsiadlo & Richardson, 1991). The 20 s or less group achieved a gait speed of at least 0.5 m/s, the minimal gait speed required for crossing a street safely (Robinett & Vondran, 1988). Older adults taking 30 s or more to perform the TUG scored in the mid- (scores 21-40) to lower (scores 0-20) tiers of the BBS, indicating a need for assistance from others or an inability to complete BBS tasks with or without assistance (Podsiadlo & Richardson, 1991). The TUG is subject to a floor effect because individuals with significant mobility impairments may be unable to complete the test in any timeframe (Beaudart et al., 2019). Podsiadlo and Richardson (1991) reported a "gray zone" for individuals performing the TUG between 20 to 29 s, with no clear association with functional status, but suggested the usefulness of evaluating changes in TUG scores to detect mobility declines or improvements over time. A minimum detectable change of 0.8-1.2 s for reduction in time was reported in older adults with hip osteoarthritis (Wright et al., 2011). A TUG score of 14 s exhibits high sensitivity (87%) and specificity (87%) in identifying fall risk in older adults (Shumway-Cook et al., 2000). The TUG has good test-retest reliability (ICC = 0.97) and excellent inter-rater reliability in an older adult population (ICC = 0.99; Podsiadlo & Richardson, 1991).

The TUG is a convenient and practical assessment of dynamic balance and gait speed in older adults (Podsiadlo & Richardson, 1991; Shumway-Cook et al., 2000). It is a quick and accurate screening tool for identifying older adults at risk for future falls (CDC, 2020; AGS/BGS, 2011). The TUG complements the results of other measures, including the BBS and SPPB, to understand important parameters of functional mobility in older adults (Beaudart et al., 2019).

Overview of recommendations for physical performance assessments

A comprehensive assessment of physical performance for older adults ideally includes testing for balance, muscular fitness, flexibility, and gait. Assessments involving performance of functional tasks in a community setting are useful because movements simulate typical activities older adults perform as part of daily life, and minimal time, space, or equipment are needed. Common assessments of physical performance for older adults include the BBS, chair stand tests, SPPB, and the TUG test. The BBS is a useful tool for assessing functional balance in older adults. Muscular fitness assessments include tests of lower extremity strength and power. The 5TSTS and 30 CST chair stand tests and the SPPB are reliable measures of functional performance in healthy older adults. The CSR and back-scratch tests are safe and effective flexibility assessments for older adults. The TUG test assesses functional mobility skills, including the coordination of dynamic balance and gait speed. Performed in combination, these assessments offer researchers a comprehensive overview of critical health- and skill-related components of physical fitness to gauge the effectiveness of exercise intervention programs for older adults.

Evidence-Based Exercise Programs for Older Adults

Public health authorities recognize certain evidence-based programs to guide health care practitioners in making safe and effective recommendations for patients and clients (CDC, 2020). Fall prevention plans for older adults include screening to detect fall risk, offering educational resources, and identifying community-based exercise programs (CDC, 2020). Tai Chi and Stay Active and Independent for Life (SAIL) are evidence-based programs recommended for community-dwelling older adults that include static and dynamic balance exercises performed in prescribed sequences (AGS/BGS, 2011; DHHS, 2018; Li, 2014; Shumway-Cook et al., 2007). Static and dynamic balance training is also prescribed in the Essentrics program, which combines elements of Tai Chi, yoga, and Pilates in a choreographed sequence of exercises (Esmonde-White, 2015;

Zarco et al., 2022). Compared to yoga and Pilates, Tai Chi is the only program recognized by public health authorities as evidence-based (CDC, 2020). Given the similarities between Tai Chi, SAIL, and Essentrics, it is useful to investigate Essentrics for possible inclusion in evidence-based recommendations made by public health authorities.

The National Council on Aging (NCOA) recommends implementation of evidence-based exercise programs to improve health behaviors, functional status, and overall well-being in older adults (NCOA, 2022a). The AGS/BGS suggested all multifactorial interventions should include an exercise component for community-dwelling older adults (AGS/BGS, 2011). The ACSM recommended exercise programming should include two or more components of aerobic exercise, strength training, balance, and flexibility exercises (Liguori et al., 2022). Additionally, the ACSM recommended neuromotor exercises challenging gait, agility, and coordination are suitable for preventing falls in older adults (AGS/BGS, 2011; Liguori et al., 2022). One program suitable for older adults that challenges balance and coordination is Tai Chi.

Tai Chi

Tai Chi training is suitable for healthy older adults (Wehner et al., 2021) and is recommended as part of fall prevention programs (AGS/BGS, 2011; DHHS, 2018; Hosseini et al., 2018; NCOA, 2022b). Tai Chi programs offered in senior community centers are adapted versions of the traditional Chinese martial art, described as "therapeutic movement exercises" (Li et al., 2018, p. 1303). Tai Chi: Moving for Better Balance (TCMBB) is an evidence-based fall prevention program recommended by the NCOA (NCOA, 2022b). The program includes modified Tai Chi movements integrating sensory, motor, and cognitive components to improve balance, gait, and functional performance and to reduce the risk of falls in older adults (Li, 2014). Participants move through a series of smooth, rhythmic exercises in various bipedal stances, initiating weight-shifting at the waist while synchronizing the breath (Li, 2014). Exercises involve functional movements important for performing ADLs, including reaching, turning, stepping, and walking (Li, 2014). Movements are slow and controlled, challenging ankle stability, lower extremity strength, and postural control through progressively challenging exercises (Li, 2014). After six months, participants in a TCMBB program showed significant improvements in functional reach, SPPB scores, and TUG test scores compared to controls (Li et al., 2018).

Research on Tai Chi has focused on general health benefits for the adult population, with emphasis placed on benefits for older adults (Hempel et al., 2014). In a systematic review of 51 randomized controlled trials, Jahnke et al. (2010) reported significant results for general health benefits for participants engaging in Tai Chi or qigong, a practice similar to Tai Chi. Postmenopausal women practicing Tai Chi reported higher bone density and a slower rate of bone loss compared to a control group (Chan et al., 2004). A 12-week Tai Chi program improved balance and abdominal muscle strength among older women with osteoarthritis with no worsening of pain or stiffness (Song et al., 2003). Long-term Tai Chi practitioners exhibited greater flexibility in the trunk and hamstrings compared to sedentary controls (Hong et al., 2000). Tai Chi improved range of motion for rotational movements of the hip and shoulder joints, essential for performing various ADLs (Hong et al., 2000). Individuals regularly engaging in Tai Chi have better postural control and lower fall rates compared to the general population

(Hong et al., 2000). After six months of participation in TCMBB, older adults at high risk of falling reported a reduction in fall incidence compared to participants who engaged in a conventional multimodal exercise program or in a stretching protocol (Li et al., 2018).

Although Tai Chi is useful for maintaining health-related components of fitness in older adults, research suggests the program may be more helpful for individuals with chronic disease or at high risk of falling compared to individuals with a higher baseline level of physical fitness (Hosseini et al., 2018; Wehner et al., 2021). Ainsworth et al. (2000) identified an average intensity level of 4 metabolic equivalents for Tai Chi programs. Song et al. (2000) found no significant difference in cardiovascular functioning for older women engaging in a 12-week Tai Chi exercise program. Older adults with greater relative strength or aerobic capacity may not experience a sufficient training stimulus when performing low intensity Tai Chi exercise compared to older adults with lower baseline levels of fitness (Wehner et al., 2021). Despite this possible limitation for older adults with higher levels of physical fitness, Tai Chi is useful in a community setting because it can be offered at low cost with no equipment. For fall prevention, the CDC (2020) recommends exercise programs such as Tai Chi must be progressively challenging and practiced 2-3 times per week for at least 50 hrs over the timeframe of program implementation.

Although Tai Chi is frequently taught in a group setting for older adults, participants in a community-based program were not motivated by socialization to engage in Tai Chi regularly (Gavin & Myers, 2003). Over a 12-week program, the dropout rate was 23%, with participants citing reasons such as feeling awkward in performing the movements and not being able to follow the exercises despite frequent repetition (Gavin & Myers, 2003). While beginners were frustrated by the complexity of the movements, other participants expressed boredom with the slow pace of Tai Chi exercises, seeking a greater challenge to improve balance, strength, and coordination (Gavin & Myers, 2003). Although similar in types of exercises, Essentrics offers a faster pace relative to Tai Chi movements, with more complex, full-body movements and frequent changes in the base of support (Zarco et al., 2022). Essentrics may provide more stimulation to participants seeking to be physically challenged while maintaining the structure and support offered in a group fitness setting.

Stay Active and Independent for Life

Stay Active and Independent for Life targets multiple risk factors for older adults at risk of falling (Pope et al., 2019). Stay Active and Independent for Life was developed by the Washington State Department of Health as a community-based fall prevention program that has been adopted by senior community centers across the U.S. (Taylor-Piliae et al., 2017). The standard format of a SAIL class includes 20 min of moderate intensity aerobic conditioning, 20 min of upper and lower body strength training, 10 min of static and dynamic balance exercises, and a 10 min stretching and falls prevention education segment (Pope et al., 2019; Shumway-Cook et al., 2007). The SAIL program accommodates individuals with moderate mobility difficulties, as the strength training segment may be performed seated or standing (Pope et al., 2019; Taylor-Piliae et al., 2017). The prescribed strength training segment includes three sets of 10 repetitions of each upper and lower body exercise (Pope et al., 2019). Upper body movements include bicep curls, triceps extensions, shoulder abduction and flexion, overhead presses, and seated crunches (Pope et al., 2019). Lower body movements, some of which may be performed while seated, include hamstring curls, hip flexion and extension, knee extension, hip abduction, and calf raises (Pope et al., 2019). Balance exercises incorporate weight shifts and changes in the base of support, such as standing with feet parallel and moving to semi-tandem stance (Pope et al., 2019). During the balance segment, participants simulate movements used in ADLs, with instructor cues such as looking to the right and left while one is walking up and down the aisles of the grocery store (Muniak et al., 2019; Pope et al., 2019). The stretching segment targets upper and lower body flexibility and includes fall prevention education, with discussion topics including medication use, home safety, and proper footwear (Pope et el., 2019; Taylor-Piliae et al., 2017).

Stay Active and Independent for Life encourages regular participation in physical activity while providing socialization and expert instruction in a group fitness setting. York et al. (2011) reported maintenance of strength and balance in healthy older adults after completing the SAIL program two or more times per week for at least 2 months. Participants in a 10-week SAIL program demonstrated faster TUG times compared to participants in a dance-based exercise intervention (Pope et al., 2019). Faster TUG times are associated with improved mobility and functional performance in older adults (Pope et al., 2019). York et al. (2011) reported an association between improved performance on physical function tests and self-reported performance of ADLs after regular participation in a SAIL exercise program. Stay Active and Independent for Life is effective for maintaining or improving functional status in older adults (Pope et al., 2019; York et al., 2011).

Participants in the SAIL program demonstrated small, significant improvements in balance, strength, and mobility, but did not report lower fall rates over a 12-month intervention period (Shumway-Cook et al., 2007). Lack of improvement in fall rates may be due to the relative low intensity in which the SAIL program is performed. The multicomponent exercises of a typical SAIL class are performed at low- to moderate-intensity (Shumway-Cook et al., 2007). Shumway-Cook et al. (2007) suggested the SAIL program may be most appropriate for older adults with lower baseline levels of strength and balance, individuals with a history of frequent falls, individuals aged 70 years or over with one or more fall risk factors, or women aged 80 years or over. Researchers emphasized the importance of social interaction and exercise adherence to gauge the suitability of the SAIL program for healthy, community-dwelling older adults (Muniak et al., 2019; Shumway-Cook et al., 2007). Participants demonstrated increased lower body strength, improved agility, and reported an increased sense of belonging after participating in an 8-week SAIL group exercise program (Muniak et al., 2019). When class was offered 3 days per week for 12 months, participants who attended class on average 2.3 times per week demonstrated greater improvements in balance and mobility performance measures compared to participants who attended less than one time per week (Shumway-Cook et al., 2007). The SAIL program is suitable for community-dwelling older adults as part of a multicomponent exercise program that encourages participants to remain physically active over the long-term (Taylor-Piliae et al., 2017).

While the SAIL program addresses several fitness components in its one-hour format, there is insufficient time to adequately address individual components. Only 10 minutes are allotted for balance training exercises, which may not allow for improvement of static and dynamic balance performance over time. The 20 min strength training segment includes upper and lower body exercises, but the 1-2 lb ankle weights provided may not be challenging to most participants. By progressively challenging participants' bases of support using body weight as the primary form of resistance, Essentrics offers a safe alternative to lower intensity programs, actively engaging participants in complex yet achievable exercises.

Essentrics

Essentrics is a low impact program consisting of gentle, full body movements, incorporating elements of Tai Chi, yoga, and Pilates (Zarco et al., 2022). The program was developed by a former ballerina, first airing on public television in the U.S. and Canada under the brand name Classical Stretch in 1999 (Esmonde-White, 2018). The program was re-branded to Essentrics and includes a network of group fitness instructors certified to teach in community settings (The Esmonde Technique, 2022). Essentrics is suitable for community settings because no equipment and minimal space is required to perform the movements (Zarco et al., 2022).

Essentrics uses slow and controlled, dynamic stretching movements of the upper and lower extremities (Zarco et al., 2022). In a group fitness setting, classes begin with exercises prescribed in the Essentrics Level One Instructor Training Manual, consisting of a 45 min session of exercises performed while standing and a 15 min session of exercises performed while seated or lying on the floor (Esmonde-White, 2018). With an older population, segments that include moving on and off the floor are recommended to be modified or removed, as up to 43% of older adults reported fear of falling when performing functional activities (Tinetti et al., 1994). The standing routine involves 4-6 min segments alternating between upper- and lower-body dominated movements (Zarco et al., 2022). After a 5 min warm-up, segments are performed as follows: shoulder blast sequence, side-to-side lunges, pliés, arm sequence, kick sequence, windmills, and calf sequence (Esmonde-White, 2018; Zarco et al., 2022). Instructors are encouraged to select music appropriate for the objective of each segment, such as upbeat music for the warm-up and kick sequence and slower music for shoulder and calf sequences (Esmonde-White, 2018). Beats per minute are recommended at a slow to moderate pace, ranging from 105 to 127, depending on the sequence (The Esmonde Technique, 2022). The objective of each sequence is to stretch and strengthen the targeted muscles (Zarco et al., 2022).

Essentrics is an accessible exercise regimen for healthy adults, with approximately 63,500 episodes of the Classical Stretch program aired in the U.S. each year (Esmonde-White, 2015). The program is marketed as "a slenderizing, strengthening, flexibility program with smooth, gentle movements set to beautiful music for all to enjoy" (Esmonde-White, 2015, p. 6). Movements incorporate concentric and eccentric muscle actions using body weight as a resistance force (Zarco et al., 2022). When cueing exercises, instructors ask participants to visualize a tall posture while pulling the extremities away from the midline of the body (Zarco et al., 2022). Instructors ask participants to envision lengthening the muscles during eccentric, dynamic stretching movements to strengthen muscles without impact to the joints (Zarco et al., 2022). Instructors cue participants to breathe naturally while performing each exercise throughout the full range of motion (Zarco et al., 2022).

Essentrics movements challenge balance by requiring weight-shifts of the torso over different positions of the feet (Esmonde-White, 2015). Participants may stand with feet parallel, shoulder-width apart, while stretching the arms toward the ceiling. During the windmill segment, feet are placed wider apart while participants lean the torso and arms over the weight-bearing leg, shifting side to side. The calf sequence involves standing in a semi-tandem stance, beginning with feet flat on the floor and plantarflexing up to standing on the toes, then returning to flat feet (Esmonde-White, 2015). Dynamic movements require adjustments to the center of pressure to maintain an upright posture (Ivanenko & Gurfinkel, 2018). Adjustments in postural control challenge sensorimotor feedback mechanisms that may decline in function in older adults (Alexander, 1994). Essentrics may contribute to the development or maintenance of strength in the lower extremities (Zarco et al., 2022). Pliés involve concentric and eccentric actions of the quadriceps and hamstrings (Esmonde-White, 2015). Eccentric muscle action causes hypertrophy by producing high tension in the muscle as it is lengthened, causing microlesions that stimulate cellular growth and repair (Hedayatpour & Falla, 2015). In Essentrics, body weight provides the mechanical load to muscles with minimal stress to the joints of the lower extremities (Esmonde-White, 2015; Zarco et al., 2022). Exercises strengthening the muscles of the lower extremities help older adults maintain sufficient mobility and gait speed to perform activities of daily living (Bonder & Del Bello-Haas, 2018; CDC, 2022; DHHS, 2018).

Essentrics includes dynamic stretching techniques to improve the range of motion of the major joints of the upper and lower body, including flexibility of the spine (Esmonde-White, 2015; Zarco et al., 2022). Instructors cue participants to lengthen and extend the fingers, wrists, elbows, and shoulders to increase range of motion of each joint (Zarco et al., 2022). Exercises involve flexion, extension, and rotation of the spinal column through slow, controlled movements (Zarco et al., 2022). Certain lower body movements include static stretches for the calves, quadriceps, and hamstrings, performed at the end of the standing phase of the Essentrics Level One Instructor Training choreographed routine (The Esmonde Technique, 2022).

When comparing modalities, Tai Chi and Essentrics use deliberate, controlled movements (Zarco et al., 2022), while SAIL uses slow and controlled movements during the balance, strength, and flexibility portions of the program (Pope et al., 2019). Essentrics incorporates more complex, full-body movements performed at a faster pace compared to Tai Chi (Zarco et al., 2022). All programs emphasize stabilizing the lower body while varying the base of support (Esmonde-White, 2015; Li, 2014; Pope et al., 2019). All programs are suitable for a community setting because space and equipment requirements are minimal (Li, 2014; Muniak et al., 2019; Zarco et al., 2022). For older adults, participation in a group setting with expert instruction is recommended to ensure safety (Cress et al., 2006). Extensive research is available on the effectiveness of Tai Chi exercise programs for older adults (Li, 2014). Public health authorities endorse Tai Chi and SAIL for improving balance, strength, and flexibility in older adults (Taylor-Piliae, et al., 2017). In comparison, research on the use of the Essentrics training program with older adults is limited.

Overall Summary

As the aging population continues to grow, health care costs associated with aging will increase accordingly. Physiological changes contributing to increased health care costs for older adults include alterations in balance, declines in muscular fitness, reduced flexibility, and changes in gait. Although typically associated with healthy aging, these changes may lead to increased fall prevalence, declines in functional performance, and loss of independence in completing activities of daily living. Public health authorities recommend multicomponent exercise programs to develop and maintain health-related components of physical fitness for older adults. These programs may include a combination of aerobic exercise, resistance training, balance training, and fall prevention education. Information in the literature supports the recommendation for older adults to engage in activities such as Tai Chi or Stay Active and Independent for Life. Essentrics is an exercise program emphasizing slow and controlled, dynamic stretching techniques to perform full-body movements while changing the base of support. Research suggests Essentrics is effective in improving strength and lean body mass in young adults; however, research on the use of the Essentrics training program with older adults is limited. Studying the effects of Essentrics on health- and skill-related fitness components for older adults is important, as the program may be a useful addition to public health recommendations for participation in a multicomponent exercise program.

CHAPTER III

EFFECTS OF ESSENTRICS TRAINING ON BALANCE AND FLEXIBILITY IN COMMUNITY-DWELLING OLDER ADULTS

Introduction

The costs associated with the physiological changes of aging are evident. Medical management of age-related conditions is costly, with average cost per capita of $6,833 in 2019, representing an increase of 41% in 10 years (Administration on Aging [AOA], 2020). Health care costs related to fall risk are of particular concern for older adults, and may include expenses for hospitalization, home health care services, placement in long-term care facilities, and durable medical equipment (Centers for Medicare & Medicaid Services [CMMS], 2021). Adults aged 65 years and older comprised 16.1% of the U.S. population in 2019, and the percentage is projected to increase to 21.6% by 2040 (AOA, 2020). Therefore, public health authorities prioritize fall prevention and preservation of functional independence among community-dwelling older adults (Centers for Disease Control & Prevention [CDC], 2020).

The American and British Geriatric Societies (AGS/BGS) recommend exercise as part of a multifactorial approach to fall prevention for older adults (AGS/BGS, 2011). The 2018 Physical Activity Guidelines for Americans recommend older adults engage in multicomponent exercise programs including a combination of two or more physical activities emphasizing aerobic endurance, muscular fitness, balance, coordination, and gait training (U.S. Department of Health and Human Services [DHHS], 2018). The

American College of Sports Medicine (ACSM) recommends inclusion of balance and coordination activities for older adults to further reduce the risk of falls (Liguori et al., 2022). Maintenance of static and dynamic balance is required to perform many activities of daily living (ADLs), and thus is important for preserving functional independence in older adults (DHHS, 2018; Shumway-Cook et al., 2007). Performing ADLs also requires flexibility of joints to complete tasks such as reaching overhead or climbing in and out of a car (AGS/BGS, 2011; DHHS, 2018). As flexibility can be impacted by joint stiffness and decreased mobility associated with aging, public health authorities recommend the inclusion of targeted flexibility exercises to maintain functional performance for older adults (AGS/BGS, 2011; DHHS, 2018).

Multicomponent exercise programs incorporating balance and flexibility exercises are recommended to maintain independence in performing ADLs and improving quality of life in older adults (DHHS, 2018). Exercise programs may be home-based or offered in the community (DHHS, 2018). Community-based exercise programs offered by senior centers may be beneficial for socialization and improved quality of life for older adults (DHHS, 2018). Examples of evidence-based exercise programs are Tai Chi: Moving for Better Balance (TCMBB) and Stay Active and Independent for Life (SAIL; Li, 2014; Shumway-Cook et al., 2007). Tai Chi and SAIL challenge static and dynamic balance by engaging in controlled, full-body movements while changing the base of support (Li, 2014; Shumway-Cook et al., 2007). While both programs have demonstrated improvements in fall reduction, some participants reported boredom due to the slow pace of movements offered by Tai Chi (Gavin & Myers, 2003; Li, 2014; Shumway-Cook et al., 2007). A group fitness program offering similar physical benefits while keeping participants actively engaged may improve exercise adherence for community-dwelling older adults.

Essentrics is a fitness training program with elements of Tai Chi, yoga, and Pilates suitable for home- or community-based participants (Esmonde-White, 2015). Essentrics uses controlled, full-body movements challenging balance and postural control through weight shifting and changes in foot positioning (Esmonde-White, 2015). In the group fitness setting, participants engage in a 60-min program of choreographed movements, alternating between upper and lower body segments and moving from standing to sitting or lying on the floor (Esmonde-White, 2018). As up to 43% of older adults have reported fear of falling when performing functional tasks requiring getting up and down from the floor, it is recommended the final segment of floor exercises is modified or removed for this population (Tinetti et al., 1994). Standing exercises involve changing the base of support, such as moving from feet parallel, to semi-tandem stance, to standing on one leg (Esmonde-White, 2018). Emphasis is placed on dynamic stretching movements, with static stretching used as part of the cooldown segment (Esmonde-White, 2018). The instructor monitors participants for safety and offers cues for proper alignment throughout the routine (Esmonde-White, 2018).

Essentrics may be a suitable addition to a multicomponent exercise program for older adults. The effects of Essentrics on strength, flexibility, and body composition have previously been investigated in young adults (Zarco et al., 2022). To date, the effects of the Essentrics training program in older adults have not been explored. Therefore, the purpose of the current study is to observe the effects of Essentrics on balance and flexibility in adults aged 65 years or older. Balance and flexibility were expected to improve after engaging in 8 weeks of Essentrics training.

Methods

Participants

The sample included male (*n* = 2) and female (*n* = 10) adults (mean age of 73 ± 6 years). Participants were recruited from fitness classes at a senior community center. Individuals were invited to participate if they were able to drive themselves to and from the center and had been engaged in a regular exercise routine for at least 3 months. Participants had been engaged in a variety of different classes at the senior community center, emphasizing cardiorespiratory fitness, muscular strength and endurance, or a combination of these components. All participants completed an Exercise Preparticipation Health Screening Questionnaire in accordance with the 2018 American College of Sports Medicine guidelines (Reibe et al., 2018), and no participants required medical clearance. The study was approved by the university Institutional Review Board and participants provided written informed consent (see Appendix A).

Outcome Variables

Berg Balance Scale

The Berg Balance Scale (BBS) was used to assess static, dynamic, and proactive balance while participants completed a series of functional tasks (Berg et al., 1989; Berg et al., 1992a; Lima et al., 2018; Muir et al., 2008). Participants performed 14 tasks, including transitioning from sitting to standing, standing unsupported with feet parallel and hip-width apart, standing unsupported with feet together, standing unsupported with eyes closed, sitting unsupported, transitioning from standing to sitting, chair transfers, reaching forward with one outstretched arm, retrieving an object from the floor, turning to look behind one's shoulder (both sides), turning 360 degrees, alternating foot taps on a bench, standing in tandem stance, and standing on one foot (Berg et al., 1992a). Participants were scored on the ability to perform a task and/or to complete the task while being timed (for example, standing on one foot for at least 10 s). Scores on each task range from 0-4, with 0 indicating the task could not be completed and 4 indicating the participant met or exceeded minimum standards for completion. Points were deducted if time or range of motion requirements were not met or if the participant required external assistance to complete a task. Participants chose which leg to use for the balance tasks and could stop the test at any time. The highest possible score on the scale is 56, with a score < 45 indicating a greater risk of falling (Berg et al., 1992a).

Chair Sit-and-Reach

The Chair Sit-and-Reach Test (CSR) is an adaptation of the traditional sit-and-reach test modified to ensure the comfort and safety of older adults (Rikli & Jones, 1999). The CSR was used to assess hamstring flexibility. Participants sat near the edge of a chair with one foot planted on the floor and the other leg extended in front of the hip with the ankle dorsiflexed. Participants were asked to lean forward and reach one hand toward the extended leg as far as possible, hold for 2 s, and return to the starting position (Rikli & Jones, 1999). While the participant held the position for 2 s, the administrator measured the distance between the participant's outstretched fingers and the toes of the dorsiflexed foot. If the participant reached past the toes, a positive score was recorded in inches, and if the participant was unable to reach the toes, a negative score was recorded in inches

(Jones & Rikli, 2002). Participants were given three attempts to complete the test, with the highest score recorded.

Back-Scratch Test

The Back-Scratch Test (BST) is a modified version of Apley's scratch test, an assessment of shoulder flexibility (Rikli & Jones, 1999). Participants were asked to reach both arms behind the back, choosing the most comfortable arm to reach overhead and reaching the other arm up the middle of the back (Jones & Rikli, 2002). If participants were able to touch the fingertips of both hands together, the administrator recorded the degree of overlap as a positive score in inches. If participants were unable to touch the fingertips together, the administrator recorded a negative score in inches. Participants were given three attempts to complete the test, with the best score recorded.

Procedures

Upon approval by the Internal Review Board, participants were recruited from a local senior community center. The principal investigator visited a variety of the center's fitness classes at different days and times across two weeks to inform prospective participants about the study. Pre-testing was conducted one week prior to the start of training. On the day of pre-testing, participants completed the Exercise Preparticipation Health Screening Questionnaire (Reibe et al., 2018) and the principal investigator answered questions about the upcoming training program. Essentrics training was conducted at the senior community center at the same time of day on Mondays and Thursdays across 8 weeks. The Essentrics training program consisted of a series of full-body, dynamic movements incorporating elements of Tai Chi, yoga, and Pilates (Zarco et al., 2022). Each of the 16 sessions included a 5 min light intensity warmup, a 30 min conditioning segment, and a 10 min cooldown and static stretching segment. All exercises were performed while standing with varying bases of support (feet placed narrowly or wide apart, standing on both legs, standing on one leg, tandem stance, etc.). For unilateral standing exercises, participants were encouraged to use the back of a chair as needed for light support, although the chair was not to be relied upon to support the participant's entire body weight. The conditioning segment included a series of 3-4 min alternating sections of upper body and lower body exercises, which incorporated body weight strengthening and stretching movements throughout each section. The instructor monitored participants for proper alignment and offered adjustments and modifications as necessary to ensure the safety of all participants. Post-testing of all outcome variables was conducted within one week after the 8-week Essentrics training program in the same manner as pre-testing.

Statistical Analysis

Descriptive statistics were reported for the Berg Balance Scale, Chair Sit and Reach, and the Back Scratch Test. A paired sample t-test was used to compare BBS test scores before and after Essentrics training. Hedge's *g* was used to report effect size. A McNemar-Bowker test was used to assess changes in Chair Sit and Reach scores (fingertips did not touch toes, fingertips touched toes, and fingertips went past the toes) between pre-testing and post-testing. A McNemar test was conducted to investigate whether Back Scratch test scores (fingertips did not touch, fingertips touched) changed after engaging in Essentrics training. An alpha of .05 was used to determine significance.

Results

Berg Balance Scale scores significantly improved from pre-training (M = 52.85, SD = 3.48, n = 13) to post-training (M = 54.00, SD = 1.68, n = 13), $t(12) = 1.87$, p = .044, Hedge's g = 0.50, 95% CI [-0.07, 1.05]. The McNemar-Bowker chi-square test indicated there was no change in Chair Sit and Reach performance from pre- to post-training, χ^2 (3, N = 13) = 6.00, p = .056. See Table 1 for frequencies.

Table 1

Frequencies for the Chair Sit and Reach Test

	Chair Sit and Reach: Pre-Test		
	Fingertips did not touch toes	Fingertips touched toes	Fingertips went past toes
Chair Sit and Reach: Post-Test			
Fingertips did not touch	2	0	0
Fingertips touched toes	1	0	0
Fingertips went past toes	2	3	5
Total	5	3	5

The Back Scratch Test measured whether participants' fingertips did not touch or fingertips overlapped from pre- to post-training. McNemar's exact test determined there was not a significant difference between pre- and post-training, p = .50. See Table 2 for frequencies.

Discussion

Multicomponent exercise programs, including community-based programs offering socialization and support, are important for maintaining independent performance of ADLs and improving quality of life for older adults (DHHS, 2018). Specifically, exercise programs incorporating balance and flexibility training are recommended to maintain functional performance later in life (AGS/BGS, 2011). The purpose of the current study was to investigate the effects of Essentrics training on assessments of balance and flexibility in community-dwelling older adults. Following Essentrics training, participants demonstrated improved balance and maintained baseline measures of flexibility.

Table 2

Frequencies for the Back Scratch Test

	Back Scratch: Pre-Test		
	Fingertips did not touch	Fingertips overlapped	Total
Back Scratch: Post-Test			
Fingertips did not touch	11	0	11
Fingertips overlapped	0	1	1
Total	11	1	12

Scores on the BBS significantly improved after 8 weeks of Essentrics training. The BBS total score is 56 points, with a range of 0-4 points measured across 14 functional tasks (Berg et al., 1992a). Participants in this study had high baseline BBS scores, with a mean score of 52.9 before engaging in the Essentrics training protocol. Prior research demonstrates a possible ceiling effect for individuals scoring at least 45 points on the BBS (Donoghue et al., 2009; Shumway-Cook et al., 1997). Following the 8-week Essentrics training intervention, the mean BBS score increased to 54.0, a change of 1.1 points. However, Donoghue et al. (2019) reported a minimum detectable change of 3.3 points for individuals scoring 45 points or more on the BBS for identifying an impact on balance during performance of functional tasks. With a mean baseline score of 52.9 points, a minimum detectable change of 3.3 points exceeds the highest possible score of 56 points; therefore, the ceiling effect was demonstrated in the current sample. Although participants demonstrated improved BBS scores after Essentrics training, the change in BBS scores did not meet the value required for minimum detectable change. Future work with participants who begin training with a lower baseline score is needed to elucidate if a change great enough to meet the minimum detectable change of the BBS would result. For individuals with high baseline scores, a more sensitive measure is needed to assess changes over time.

Additionally, based on the baseline scores, participants in this study were not at risk of falling within the next year. This is based on Shumway-Cook et al. (1997) who indicated the BBS is useful for identifying individuals who are not at risk of falling, with a suggested cutoff score of 45. Further, Lima et al. (2018) reported a cutoff score of ≤ 50 for identifying individuals at risk of falling within the next 12 months. The ability of Essentrics training to impact fall risk should be investigated in those with a higher initial fall risk.

Exercises in the Essentrics program are designed to challenge static and dynamic balance (Esmonde-White, 2015), which are physiological mechanisms affected by advancing age (AGS/BGS, 2011; Bergen et al., 2019; Liguori et al., 2022; Lusardi et al., 2003). Consistent engagement in multicomponent exercise programs is recommended to prevent age-related declines in functional performance (DHHS, 2018), including the incorporation of neuromotor exercises challenging balance and coordination (Liguori et al., 2022). Essentrics exercises requiring shifting of body weight over varying bases of support simulate movements used in ADLs (Esmonde-White, 2015). While balance is expected to decline as individuals age, participants engaged in the 8-week Essentrics program demonstrated improvement in functional movements requiring static and dynamic balance. Regular engagement in the Essentrics training program may support maintenance of balance in older adults with baseline BBS scores of 45 points or more.

The current study investigated the effects of Essentrics training on flexibility as measured by the modified CSR and BST. In agreement with the findings of Zarco et al. (2022) in young adults, there was no significant change in measures of upper or lower body flexibility in the participants in this study. In the CSR, participants who could not touch fingertips to toes during pre-testing were still not able to touch fingertips to toes after the 8-week Essentrics intervention. There were five participants with high baseline values at pre-testing. These individuals were able to reach past their toes prior to engaging in Essentrics training and were still able to do so after training. Given the small sample size of the current study, CSR changes may be significant with more participants. An assessment that is appropriate for older adults with a larger sample size is encouraged to be incorporated into future work.

Like results reported for lower body flexibility, there was no significant change in upper body flexibility in the current study. At pre-testing, only one participant had fingertips overlap behind the back in the BST, and 11 participants were unable to touch fingertips behind the back. These values did not change after Essentrics training. Using bodyweight as the only form of resistance, Essentrics focuses on dynamic stretching of lower body muscles (Esmonde-White, 2015). Stretches for upper body musculature are included in the program, but it is possible the training load is insufficient to produce significant change in upper body flexibility. Increasing training frequency to three or more times per week and/or extending the program longer than eight weeks could affect flexibility outcomes reported in older adults.

Although there was no significant improvement in measures of flexibility following the Essentrics program, participants maintained the initial category of flexibility achieved in the CSR and BST across the 8-week period. As a measure of lower body flexibility, the CSR measures ROM at the hip joint only. The final segment of the Essentrics program involves static stretching of the lower leg, including dorsiflexion of the ankle joint. In addition to hip extensibility, sufficient ankle dorsiflexion is required for functional mobility tasks such as crossing the street safely (Christiansen, 2008). Including assessments for ROM at the ankle joint may provide additional information as to the utility of the Essentrics program for maintaining the flexibility necessary for completing certain ADLs.

Research conducted on the SAIL training program indicates participation in a group fitness setting increases exercise adherence and promotes socialization for older adults (Muniak et al., 2019; Shumway-Cook et al., 2007). In a 12-month SAIL program, participants who attended class an average of 2.3 times per week maintained balance compared to participants who attended one or fewer times per week (Shumway-Cook et al., 2007). Participants in the current study attended an average 14 of 16 sessions, demonstrating a positive trend in exercise adherence as reported in prior research (Shumway-Cook et al., 2007).

Similar to Tai Chi, Essentrics involves controlled movements using body weight as resistance (Zarco et al., 2022). Older adults have reported boredom when engaged in Tai Chi classes due to the slow pace at which exercises are performed (Gavin & Meyers, 2003). The Essentrics program offered in a community setting by professional instructors involves safe and effective movements performed at a faster pace compared to traditional

Tai Chi fitness programs. Essentrics classes led by professional fitness instructors are further enhanced by using a selection of music likely to appeal to older adults, thus increasing enjoyment and improving exercise adherence. Consistent attendance in group fitness programs led by qualified instructors, including Essentrics, may lead to improved physical and mental health outcomes in older adults.

Essentrics may be a useful addition to the selection of multicomponent exercise programs recommended by public health authorities for older adults (CDC, 2020; DHHS, 2018). Essentrics programs offered in a community setting require no equipment and minimal space. Classes led by qualified fitness instructors ensure proper monitoring and safety of participants. Group fitness classes offer opportunities for socialization, and consistent engagement in activities has been shown to improve quality of life in older adults (DHHS, 2018). Essentrics may be suitable for improving or maintaining balance, a skill-related component of fitness necessary for performing ADLs. While declines in balance and flexibility are expected to occur with aging, regular participation in multicomponent exercise programs, including Essentrics, may facilitate maintenance of baseline physiological measures of fitness in older adults.

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APPENDIX FOR STUDY I

APPENDIX A

IRB Approval Letter

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129
FWA: 00005331/IRB Regn. 0003571

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Monday, May 03, 2021

Protocol Title	***Essentrics for Balance Training and Physical Function in Older Adults***
Principal Investigator	**Merredith Mooth** (Student)
Faculty Advisor	Jenn Caputo
Co-Investigators	Sandra Stevens, Samantha Johnson and *Elizabeth Smith
Investigator Email(s)	*merredith.mooth@mtsu.edu; jenn.caputo@mtsu.edu*
Department	Health & Human Performance - Exercise Science and *Nutrition & Food Science
Funding	**NONE**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU IRB through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within the category *(4) Collection of data through noninvasive procedures* under the sub-classification E: *moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.* A summary of the IRB action is tabulated below:

IRB Action	**APPROVED for ONE YEAR**		
Date of Expiration	**5/31/2022**	*Date of Approval*: 5/3/21	*Recent Amendment*: NONE
Sample Size	FIFTY (50)		
Participant Pool	*Target Population:* Primary Classification: **Older Adults (50 to 80 years of age)** Specific Classification: **Community-dwelling (independently living)**		
Type of Interaction	☐ Non-interventional or Data Analysis ☐ Virtual/Remote/Online interaction ☒ **In person or physical interaction – Mandatory COVID-19 Management**		
Exceptions	1. Permitted to recruit participants over 65 years of age with screening. 2. Participant details are allowed for furuture recruitment. 3. Participant infomration allowed for COVID-19 management		
Restrictions	**1. Mandatory SIGNED Informed Consent.** **2. Other than the exceptions above, identifiable data/artifacts, such as, audio/video data, photographs, handwriting samples, personal address, driving records, social security number, and etc., MUST NOT be collected. Recorded identifiable information must be deidentified as described in the protocol.** **3. Mandatory Final report (refer last page).** **4. Mandatory participant screening for avoiding risky participants.** **5. CDC guidelines and MTSU safe practice must be followed.**		
Approved Templates	*IRB Templates:* Signature informed consent *Non-MTSU Templates:* Recruitment scripts		
Research Inducement	NONE		
Comments	NONE		

Post-approval Requirements

The PI and FA must read and abide by the post-approval conditions (Refer "*Quick Links*" in the bottom):

- ***Reporting Adverse Events:*** The PI must report research-related adversities suffered by the participants, deviations from the protocol, misconduct, and etc., within 48 hours from when they were discovered.
- ***Final Report:*** The FA is responsible for submitting a final report to close-out this protocol before **5/31/2022** **(Refer to the Continuing Review section below)**; REMINDERS WILLNOT BE SENT. **Failure to close-out or request for a continuing review may result in penalties** including cancellation of the data collected using this protocol and/or withholding student diploma.
- ***Protocol Amendments***: An IRB approval must be obtained for all types of amendments, such as: addition/removal of subject population or investigating team; sample size increases; changes to the research sites (appropriate permission letter(s) may be needed); alternation to funding; and etc. The proposed amendments must be requested by the FA in an addendum request form. The proposed changes must be consistent with the approval category and they must comply with expedited review requirements
- ***Research Participant Compensation:*** Compensation for research participation must be awarded as proposed in Chapter 6 of the Expedited protocol. The documentation of the monetary compensation must Appendix J and MUST NOT include protocol details when reporting to the MTSU Business Office.
- ***COVID-19:*** Regardless whether this study poses a threat to the participants or not, refer to the COVID-19 Management section for important information for the FA.

Continuing Review (The PI has requested early termination)

Although this protocol can be continued for up to THREE years, The PI has opted to end the study by **5/31/2022** **The PI must close-out this protocol by submitting a final report before 5/31/2022 Failure to close-out may result in penalties that include cancellation of the data collected using this protocol and delays in graduation of the student PI.**

Post-approval Protocol Amendments:

The current MTSU IRB policies allow the investigators to implement minor and significant amendments that would fit within this approval category. ***Only TWO procedural amendments will be entertained per year*** *(changes like addition/removal of research personnel are not restricted by this rule).*

Date	Amendment(s)	IRB Comments
NONE	NONE.	NONE

Other Post-approval Actions:

The following actions are done subsequent to the approval of this protocol on request by the PI/FA or on recommendation by the IRB or by both.

Date	IRB Action(s)	IRB Comments
NONE	NONE	NONE

COVID-19 Management:

The PI must follow social distancing guidelines and other practices to avoid viral exposure to the participants and other workers when physical contact with the subjects is made during the study.

- The study must be stopped if a participant or an investigator should test positive for COVID-19 within 14 days of the research interaction. This must be reported to the IRB as an "adverse event."
- The MTSU's "Return-to-work" questionnaire found in Pipeline must be filled by the investigators on the day of the research interaction prior to physical contact.
- PPE must be worn if the participant would be within 6 feet from the each other or with an investigator.
- Physical surfaces that will come in contact with the participants must be sanitized between use
- **FA's Responsibility:** The FA is given the administrative authority to make emergency changes to protect the wellbeing of the participants and student researchers during the COVID-19 pandemic. However, the FA must notify the IRB after such changes have been made. The IRB will audit the changes at a later date and the FA will be instructed to carryout remedial measures if needed.

Data Management & Storage:

All research-related records (signed consent forms, investigator training and etc.) must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data must be stored for at least three (3) years after the study is closed. Additional Tennessee State data retention requirement may apply (*refer "Quick Links" for MTSU policy 129 below*). The data may be destroyed in a manner that maintains confidentiality and anonymity of the research subjects.

The MTSU IRB reserves the right to modify/update the approval criteria or change/cancel the terms listed in this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

- Post-approval Responsibilities: http://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities.php
- Expedited Procedures: https://mtsu.edu/irb/ExpeditedProcedures.php
- MTSU Policy 129: Records retention & Disposal: https://www.mtsu.edu/policies/general/129.php

CHAPTER IV

THE EFFECTS OF ESSENTRICS TRAINING ON MUSCULAR FITNESS AND FUNCTIONAL MOBILITY IN COMMUNITY-DWELLING OLDER ADULTS

Introduction

In the United States, 41% of the "baby boom" population is now aged 65 years or older, a demographic termed "older adults" (Administration on Aging [AOA], 2020). In 2019, there were 54.1 million older adults in the U.S., and this number is expected to grow to 80.8 million by 2040 (AOA, 2020). The cost of care increases exponentially as older adults transition from living in the community to needing more advanced levels of care (AOA, 2020; CMMS, 2021). With the advancing age of the population, these health care expenditures are increasingly absorbed by Medicaid and Medicare, U.S. Federal agencies operating within considerable budgetary constraints (CMMS, 2021). Therefore, public health authorities recognize the cost advantages of maintaining independence throughout the lifespan (CMMS, 2021).

The ability to perform activities of daily living (ADLs) is critical to maintaining independence (Bonder & Dal Bello-Haas, 2018). Completing ADLs requires preservation of muscular fitness and functional mobility (Bonder & Dal Bello-Haas, 2018). Age-related declines in muscular fitness include declines in muscle strength and power, which lead to increased fall risk and decreased functional performance (American Geriatrics Society & British Geriatric Society [AGS/BGS], 2011). Sarcopenia is a skeletal muscle disorder associated with low muscle strength, slow gait speed, and declines in physical performance in older adults (Bhasin et al., 2020; Billot et al., 2020; Cruz-Jentoft et al., 2019; Tieland et al., 2018). Delaying the progression of sarcopenia and concomitant declines in physical performance are therefore important goals for maintaining independence for older adults (Cruz-Jentoft et al., 2019).

Maintenance of gait speed is also an essential element to ensuring functional mobility and safety of older adults (Cruz-Jentoft et al., 2018; Freiberger et al., 2020). A gait speed slower than 1 m/s is associated with increased risk of falls, increased rates of hospitalization, and death (Cesari et al., 2005; Fritz & Lusardi, 2009; Middleton et al., 2015; Ruggero et al., 2013). Slow gait speed is an indicator of sarcopenia and a predictor of adverse health outcomes in older adults (Bhasin et al., 2020). Maintenance of gait speed is therefore a key element in preserving functional performance outcomes for older adults.

While healthy aging is associated with declines in these physical performance measures (AGS/BGS, 2011), engaging in structured exercise can develop or maintain muscular fitness (AGS/BGS, 2011; CDC, 2020; DHHS, 2018). The CDC recommends older adults engage in multicomponent activities requiring different types of movement, including walking, strength training, yoga, and Tai Chi to challenge balance and coordination while developing aerobic and muscular fitness (CDC, 2022). The U.S. Physical Activity Guidelines recommend adults perform muscle strengthening activities for all major muscle groups on two or more days per week (DHHS, 2018). As an alternative to traditional strength training activities, another option is Essentrics, a targeted fitness training program suitable for older adults (Esmonde-White, 2015). Essentrics uses full-body movements with minimal stress to the joints, thus offering an option for older adults to engage in a regular exercise program (Esmonde-White, 2015). While Zarco et al. (2022) investigated the effects of Essentrics on strength, flexibility, and body composition in young adults, Essentrics as a strength training and functional mobility program for older adults has not been explored. Therefore, the purpose of the current study was to observe outcome measures of muscular fitness and functional mobility in adults aged 65 years or older following an 8-week Essentrics program. Muscle fitness and functional mobility were expected to improve after participating in Essentrics training.

Methods

Participants

Older adults (*N* = 12, male *n* = 2, female *n* = 10) with a mean age of 73 ± 6 years participated in the study. Participants were community-dwelling older adults engaging in group fitness classes at a local senior community center for at least 3 months. Classes at the center were multicomponent programs including aerobic fitness, muscular strength, balance, and flexibility. Inclusion criteria included the ability to drive to and from the center and to ambulate without the use of an assistive device. The study was approved by the Institutional Review Board of the university and participants provided written informed consent (see Appendix A).

Outcome Variables

Short Physical Performance Battery

The Short Physical Performance Battery (SPPB) is a valid and reliable measure of balance, usual gait speed, and lower body strength in healthy adults aged 60 years or over (Beauchamp et al., 2014; Beaudart et al., 2019; Guralnik et al., 1994; Kameniar et al., 2022). The components are assessed using a three-stage balance test, a gait speed test consisting of two trials, and two chair stand tests (Ronai & Gallo, 2019). The balance test began with participants standing with feet parallel, progressed to a semi tandem stance, and finished with a tandem stance. The gait speed test involved walking 4 m at the participants' usual gait speed for two trials, with the fastest time recorded as the score for that segment (Ronai & Gallo, 2019). In the first chair stand test, participants rose from a chair in a single instance with arms folded across the chest. The second chair stand was a five-time-sit-to-stand (5TSTS), in which participants were asked to rise from a chair and return to sitting five times without stopping (Ronai & Gallo, 2019). The three assessment scores combine to a potential score of 12 points, with a score of 10 or greater associated with sufficient balance, gait speed, and lower extremity muscle strength to perform ADLs independently (Guralnik et al., 1994; Ronai & Gallo, 2019). As a comprehensive assessment measuring balance, mobility, and strength, the total score on the SPPB is an indicator of functional performance for older adults (Guralnik et al., 1994; Ronai & Gallo, 2019).

Timed-Up-and-Go Test

The Timed-Up-and-Go (TUG) test is an objective measurement of functional mobility, essential for performing many ADLs (Podsiadlo & Richardson, 1991). The AGS/BGS and CDC recommend the TUG test to identify older adults at high risk of falling (AGS/BGS, 2011; CDC, 2020). The investigator placed a chair against a wall and placed a marker on the floor 3 m in front of the chair (Beaudart et al., 2019). The test began with each participant sitting in the chair with feet placed flat on the floor. Participants were asked to rise from the chair, walk 3 m at their usual pace, turn around, walk back to the chair, and sit down while the investigator recorded the time required to complete the test (Beaudart et al., 2019). As a measure of functional mobility, a TUG time of 20 s or less is associated with the ability to perform ADLs independently, as a gait speed of at least 0.5 m/s is required to cross a street safely (Podsiadlo & Richardson, 1991; Robinett & Vondran, 1988).

30-Second Chair Stand

The 30-Second Chair Stand Test (30 CST) measures the number of sit-to-stand transitions a participant can perform in 30 s (Rikli & Jones, 1999). Participants sat in a chair with feet flat on the floor and arms folded across the chest (Rikli & Jones, 1999). When the investigator started the timer, participants rose to a standing position and returned to a seated position, repeating as many sit-to-stand transitions as possible within the 30 s timeframe (Rikli & Jones, 1999). Rikli and Jones (1999) reported chair stand performance declines with age, with individuals aged 60-69 years averaging 14 sit-to-stand transitions per 30 s, individuals aged 70-79 averaging 12.9 sit-to-stand transitions, and individuals aged 80-89 averaging 11.9 sit-to-stand transitions. Criterion validity of the 30 CST indicates the test correlates moderately high with one repetition maximum leg press performance for men ($r = .78$) and women ($r = .71$), a measure of lower extremity strength associated with performance of various ADLs (Rikli & Jones, 1999). Test-retest reliability is 0.84 for men and 0.92 for women (Rikli & Jones, 1999). The 30 CST is therefore a valid and reliable measurement of lower extremity muscle strength in older adults.

Procedures

The study was approved by the university Institutional Review Board and recruitment efforts commenced at the local senior community center. Participants were recruited by word of mouth, with the principal investigator announcing the study during several fitness classes at the center. During the pre-training assessment session, participants completed the Exercise Preparticipation Screening Health Questionnaire following the 2018 American College of Sports Medicine guidelines (Reibe et al., 2018). Responses indicated no participants required medical clearance. Participants also completed the physical performance assessments (SPPB, TUG test, and 30 CST) during this initial session.

The Essentrics training program was led by the principal investigator at the senior community center on Mondays and Thursdays across 8 weeks. Each session was 45 min in length and consisted of a 5 min warm-up, a 30 min conditioning segment, and a 10 min cooldown. For safety reasons, the original 60 min format was shortened by removing exercises performed on the floor, completing only standing exercises for 45 min. The conditioning segment consisted of a series of alternating upper and lower body dynamic stretching and strengthening exercises using body weight as the only form of resistance. The warm-up simulated movements included in the conditioning segment, and the cooldown included lower body static stretches. Participants were encouraged to breathe naturally and to self-monitor for any signs of discomfort. Additionally, the instructor monitored participants throughout all segments and offered modifications as necessary to maintain safe and proper alignment. Post-testing was conducted for all outcome variables after 8 weeks of training.

Statistical Analysis

Descriptive statistics were reported for the Short Physical Performance Battery, Timed-Up-and-Go, and 30-Second Chair Stand tests. A paired sample t-test was used to compare pre-test scores to post-test scores after Essentrics training for the SPPB, TUG, and 30 CST tests. An alpha of .05 was used to determine significance. Hedge's *g* effect sizes were also reported.

Results

There was significant improvement in SPPB scores from pre- (M = 9.88, SD = 0.35, n = 8) to post-training (M = 11.63, SD = 0.74, n =8), $t(7) = 10.69$, $p < .001$, Hedge's g = 3.57, 95% CI [1.62, 5.51]. Timed-Up-and-Go scores improved from pre- (M = 9.29, SD = 2.00, n = 13) to post-test (M = 8.31, SD = 1.03, n = 13), $t(12) = 2.14$, $p = .027$, Hedge's g = 0.58, 95% CI [−.01, 1.14]. Finally, scores for the 30-s Chair Stand Test improved from pre- (M = 12.62, SD = 4.29, n = 13) to post-test (M = 15.92, SD = 2.50, n = 13), $t(12) = 4.66$, $p < .001$, Hedge's g = 1.25, 95% CI [0.51, 1.96].

Discussion

Public health authorities recognize the importance of engaging in regular exercise to maintain health- and skill-related components of physical fitness in older adults (AGS/BGS, 2011; CMMS, 2021; DHHS, 2018). Specifically, multicomponent exercise programs are recommended, including programs focusing on development and maintenance of muscular fitness and functional mobility (CDC, 2020; DHHS, 2018). Assessments of functional mobility, including tests for usual gait speed, are important for determining the ability of older adults to perform ADLs independently (AGS/BGS, 2011; CDC 2020). The purpose of the current study was to determine the effects of Essentrics training on tests of muscular fitness and functional mobility in community-dwelling older adults. Participants demonstrated improved measures of muscular fitness and functional mobility following an 8-week, twice weekly Essentrics training intervention.

Composite scores of the three-component SPPB significantly improved following Essentrics training. Perracini et al. (2020) reported the total SPPB score was a better predictor of functional performance declines compared to measures of individual components (the three-stage balance, usual gait speed, and two chair stand tests). Based on a total score of 12 points, participants in the current study had baseline values averaging 9.9 points. Following Essentrics training, participants scored an average of 11.6 points on the SPPB, a 1.7-point improvement. A minimum detectable change of 1.0 point on the SPPB is necessary for determining declines or improvements in physical function in healthy older adults (Kwon et al., 2009; Perera et al., 2014). A score of 10 points or greater is associated with independent performance of ADLs (Guralnik et al., 1994; Ronai & Gallo, 2019). Notably, participants in the current study averaged below 10 points on the SPPB at pre-testing and averaged above 10 points at post-testing. Although baseline measures were below the threshold, the improvement in SPPB scores was sufficient to move participants into the range associated with independent performance of ADLs. As measured by total score on the SPPB, Essentrics training supports the development and maintenance of balance, lower body muscular fitness, and functional mobility for older adults to perform ADLs independently.

Like the gait speed component of the SPPB, participants in the current study showed significant improvement in TUG scores from pre-testing to post-testing. The TUG test assesses not only usual gait speed but also requires performance of functional movements such as rising from and returning to a chair and turning around while walking (Podsiadlo & Richardson, 1991). At pre-testing, participants averaged 9.3 s while completing the 3 m test and at post-testing, participants averaged 8.3 s. A TUG time of 20 s or less is associated with sufficient functional mobility to perform ADLs independently (Podsiadlo & Richardson, 1991). Baseline scores for participants in this study indicated an ability to perform ADLs independently before engaging in Essentrics training. Although the 1 s average improvement in TUG scores was statistically significant, it is unlikely to have affected certain measures of functional mobility, such as the 0.5 m/s gait speed required to cross a street (Podsiadlo & Richardson, 1991; Robinett & Vondran, 1988). Participants with high baseline values (20 s or less) on the TUG would be expected to possess the functional mobility required to perform this task safely. The effect of Essentrics training on measures of functional mobility should be explored in individuals with TUG times of greater than 20 s.

The 30 CST is an assessment of lower body muscular strength and power, as the test involves counting the number of sit-to-stand transitions participants are able to complete in 30 s (Rikli & Jones, 1999). Participants demonstrated significant improvement in the 30 CST after engaging in Essentrics training. The average number of sit-to-stand transitions recorded at pre-testing was 12.6, and at post-testing the average number of transitions was 15.9. Rikli and Jones (1999) reported declines in 30 CST performance with advancing age, from 14.0 sit-to-stand transitions in individuals aged 60-69 years to 12.9 sit-to-stand transitions in individuals aged 70-79 years. The mean age of participants in the current study was 73 ± 6 years. Participants began the study performing an age-appropriate average of 12.6 sit-to-stand transitions. Following

Essentrics training, participants demonstrated a higher number of sit-to-stand transitions compared to age-matched individuals (70-79 years). The average improvement in 30 CST scores was sufficient to place participants in line with individuals who were 10 years younger, suggesting a positive impact of Essentrics on physical performance outcomes. Consistent engagement in the Essentrics program at least two times per week may support development or maintenance of lower body muscular fitness in older adults.

Essentrics is a suitable addition to multicomponent exercise programs recommended for older adults. The CDC recommends engaging in different activities to develop aerobic and muscular fitness, including strength training, yoga, and Tai Chi (CDC, 2020). Additionally, the U.S. Physical Activity Guidelines recommend older adults follow the same strength training guidelines as healthy adults aged 18 years or over, performing muscle strengthening activities on two more days per week (DHHS, 2018). Essentrics is a low impact program using only body weight as resistance (Esmonde-White, 2015), and may have lower risk of injury for older adults compared to traditional strength training activities, such as using free weights or weight machines. Community-based Essentrics programs may be convenient for older adults without access to health club facilities, as Essentrics exercises do not require the use of equipment.

In addition to positive effects on muscular fitness, regular engagement in Essentrics training may support maintenance of functional mobility in older adults. Significant improvement in measures of usual gait speed in the SPPB and the TUG may prevent or delay adverse health outcomes in older adults, as slow gait speed is associated with development of sarcopenia (Bhasin et al., 2020). By simulating everyday movements requiring shifts in body weight over varying bases of support, Essentrics may provide a sufficient training stimulus for older adults to maintain independence in performance of ADLs (Esmonde-White, 2015). While the current study removed floor exercises, modifying these exercises for older adults would allow for a longer duration of each session, which could lead to greater training stimulus.

Community-based exercise programs are also recommended for older adults because of the opportunities offered for socialization (DHHS, 2018; Muniak et al., 2019; Shumway-Cook et al., 2007). In a group fitness setting, participants can be monitored for safety by qualified instructors (Esmonde-White, 2015). As an accessible, community-based program, engaging in Essentrics two times per week may offer older adults an enjoyable alternative to other group fitness classes offering free-weight strength training exercises while supporting maintenance of functional performance.

Chapter IV References

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APPENDIX FOR STUDY II

APPENDIX A

IRB Approval Letter

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129
FWA: 00005331/IRB Regn. 0003571

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Monday, May 03, 2021

Protocol Title	***Essentrics for Balance Training and Physical Function in Older Adults***
Principal Investigator	**Merredith Mooth** (Student)
Faculty Advisor	Jenn Caputo
Co-Investigators	Sandra Stevens, Samantha Johnson and *Elizabeth Smith
Investigator Email(s)	*merredith.mooth@mtsu.edu; jenn.caputo@mtsu.edu*
Department	Health & Human Performance - Exercise Science and *Nutrition & Food Science
Funding	**NONE**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU IRB through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within the category *(4) Collection of data through noninvasive procedures* under the sub-classification E: *moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.* A summary of the IRB action is tabulated below:

IRB Action	**APPROVED for ONE YEAR**		
Date of Expiration	**5/31/2022**	*Date of Approval*: 5/3/21	*Recent Amendment*: NONE
Sample Size	FIFTY (50)		
Participant Pool	*Target Population:* Primary Classification: **Older Adults (50 to 80 years of age)** Specific Classification: **Community-dwelling (independently living)**		
Type of Interaction	☐ Non-interventional or Data Analysis ☐ Virtual/Remote/Online interaction ☒ **In person or physical interaction – Mandatory COVID-19 Management**		
Exceptions	1. Permitted to recruit participants over 65 years of age with screening. 2. Participant details are allowed for furuture recruitment. 3. Participant infomration allowed for COVID-19 management		
Restrictions	**1. Mandatory SIGNED Informed Consent.** **2. Other than the exceptions above, identifiable data/artifacts, such as, audio/video data, photographs, handwriting samples, personal address, driving records, social security number, and etc., MUST NOT be collected. Recorded identifiable information must be deidentified as described in the protocol.** **3. Mandatory Final report (refer last page).** **4. Mandatory participant screening for avoiding risky participants.** **5. CDC guidelines and MTSU safe practice must be followed.**		
Approved Templates	*IRB Templates:* Signature informed consent *Non-MTSU Templates:* Recruitment scripts		
Research Inducement	NONE		
Comments	NONE		

Post-approval Requirements

The PI and FA must read and abide by the post-approval conditions (Refer "*Quick Links*" in the bottom):

- ***Reporting Adverse Events:*** The PI must report research-related adversities suffered by the participants, deviations from the protocol, misconduct, and etc., within 48 hours from when they were discovered.
- ***Final Report:*** The FA is responsible for submitting a final report to close-out this protocol before **5/31/2022** **(Refer to the Continuing Review section below)**; REMINDERS WILLNOT BE SENT. **Failure to close-out or request for a continuing review may result in penalties** including cancellation of the data collected using this protocol and/or withholding student diploma.
- ***Protocol Amendments***: An IRB approval must be obtained for all types of amendments, such as: addition/removal of subject population or investigating team; sample size increases; changes to the research sites (appropriate permission letter(s) may be needed); alternation to funding; and etc. The proposed amendments must be requested by the FA in an addendum request form. The proposed changes must be consistent with the approval category and they must comply with expedited review requirements
- ***Research Participant Compensation:*** Compensation for research participation must be awarded as proposed in Chapter 6 of the Expedited protocol. The documentation of the monetary compensation must Appendix J and MUST NOT include protocol details when reporting to the MTSU Business Office.
- ***COVID-19:*** Regardless whether this study poses a threat to the participants or not, refer to the COVID-19 Management section for important information for the FA.

Continuing Review (The PI has requested early termination)

Although this protocol can be continued for up to THREE years, The PI has opted to end the study by **5/31/2022** **The PI must close-out this protocol by submitting a final report before 5/31/2022 Failure to close-out may result in penalties that include cancellation of the data collected using this protocol and delays in graduation of the student PI.**

Post-approval Protocol Amendments:

The current MTSU IRB policies allow the investigators to implement minor and significant amendments that would fit within this approval category. ***Only TWO procedural amendments will be entertained per year*** *(changes like addition/removal of research personnel are not restricted by this rule).*

Date	Amendment(s)	IRB Comments
NONE	NONE.	NONE

Other Post-approval Actions:

The following actions are done subsequent to the approval of this protocol on request by the PI/FA or on recommendation by the IRB or by both.

Date	IRB Action(s)	IRB Comments
NONE	NONE	NONE

COVID-19 Management:

The PI must follow social distancing guidelines and other practices to avoid viral exposure to the participants and other workers when physical contact with the subjects is made during the study.

- The study must be stopped if a participant or an investigator should test positive for COVID-19 within 14 days of the research interaction. This must be reported to the IRB as an "adverse event."
- The MTSU's "Return-to-work" questionnaire found in Pipeline must be filled by the investigators on the day of the research interaction prior to physical contact.
- PPE must be worn if the participant would be within 6 feet from the each other or with an investigator.
- Physical surfaces that will come in contact with the participants must be sanitized between use
- **FA's Responsibility:** The FA is given the administrative authority to make emergency changes to protect the wellbeing of the participants and student researchers during the COVID-19 pandemic. However, the FA must notify the IRB after such changes have been made. The IRB will audit the changes at a later date and the FA will be instructed to carryout remedial measures if needed.

Data Management & Storage:

All research-related records (signed consent forms, investigator training and etc.) must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data must be stored for at least three (3) years after the study is closed. Additional Tennessee State data retention requirement may apply (*refer "Quick Links" for MTSU policy 129 below*). The data may be destroyed in a manner that maintains confidentiality and anonymity of the research subjects.

The MTSU IRB reserves the right to modify/update the approval criteria or change/cancel the terms listed in this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

- Post-approval Responsibilities: http://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities.php
- Expedited Procedures: https://mtsu.edu/irb/ExpeditedProcedures.php
- MTSU Policy 129: Records retention & Disposal: https://www.mtsu.edu/policies/general/129.php

CHAPTER V

OVERALL CONCLUSIONS

The purpose of this dissertation was to evaluate the outcomes of Essentrics training on functional performance in community-dwelling older adults. In the first study, the effects of Essentrics on measures of static and dynamic balance and flexibility were assessed. In the second study, the effects of Essentrics on measures of muscular fitness and functional mobility were evaluated.

The dissertation included one group of older adults aged 73 ± 6 years who had been exercising at the local senior community center for at least three months. Participants continued in their current exercise programs while adding the Essentrics training protocol two times per week for eight weeks. The intervention consisted of pre-testing one week before training commenced and post-testing occurred within one week after the end of the program. No participants required medical clearance prior to engaging in Essentrics, and no adverse events were reported during the training intervention.

Measures of physical performance outcomes included the BBS, CSR, BST, SPPB, TUG, and 30 CST. Participants demonstrated significant improvements in scores on the BBS, SPPB, TUG, and 30 CST. There was no significant change in measures of lower or upper body flexibility as assessed by the CSR and BST. Before engaging in the Essentrics training program, participants had a high average baseline score on the BBS, scoring above the cutoff of 45 points or more. Scores below 45 are associated with an adverse impact on balance in the performance of functional tasks (Donogue et al., 2019).

Even so, participants demonstrated an increase of 1.1 point on the BBS at post-testing. While this level of improvement did not meet the 3.3 point minimum detectable change required to be a meaningful improvement in functional performance, this may be associated with the higher starting baseline. Participants maintained static and dynamic balance throughout the 8-week Essentrics program; however, it is important to note they continued to engage in multicomponent exercise classes outside of Essentrics, including performance of activities involving aerobic fitness and muscular strength. Although no significant change was observed for measures of flexibility, baseline levels of joint ROM were maintained across the 8-week period. While engaging in Essentrics training, participants did not exhibit any loss of joint ROM as would be expected with typical healthy aging.

Unlike changes in BBS scores, the improvement in SPPB scores exceeded the 1.0-point minimum threshold required to observe meaningful changes in functional performance outcomes. Baseline SPPB scores averaged below the 10-point threshold associated with independent performance of ADLs. After 8 weeks of Essentrics training, participants demonstrated significant improvement in functional performance outcomes as measured by average composite scores on the three-part SPPB, scoring above the 10-point threshold. Consistent with improved scores on the usual gait speed test of the SPPB, participants also demonstrated significant improvements in TUG times. However, average baseline times of 9.3 s outperformed the minimum time of 20 s or greater on the TUG associated with declines in usual gait speed and functional mobility outcomes. Although participants improved TUG times by an average of 1.0 s, this is unlikely to impact individual performance of ADLs such as crossing the street. Finally, changes in the 30 CST were significant, moving participants from an average age-matched score at pre-testing to an above-average score at post-testing.

Overall, the results of these studies indicate engaging in a twice weekly Essentrics training program for eight weeks leads to significant improvements in lower body muscular fitness as determined by scores on the 30 CST. Measures of static and dynamic balance were also positively impacted, as indicated by BBS scores. Participants maintained or improved measures of functional mobility as demonstrated by SPPB scores and TUG times. Like previous findings in young adults (Zarco et al., 2022), participants in the current studies did not exhibit meaningful changes in flexibility. Future research could examine the effects of Essentrics on physical performance in older adults with lower baseline levels of fitness. In healthy older adults, extended duration or increased frequency of the Essentrics program offered in a community setting should be explored to determine if minimum detectable change values are realized on physical outcome measures such as the BBS and TUG.

Public health recommendations for the maturing population are designed to encourage multicomponent exercise programs to support community-dwelling older adults in maintaining independence throughout the lifespan. With positive effects on balance, muscular fitness, and functional mobility, Essentrics is a suitable addition to existing multicomponent exercise programs for older adults such as Tai Chi, SAIL, and strength training activities. Emphasizing postural control with minimal impact on joints, Essentrics is a safe training program in which healthy, community-dwelling older adults may engage. Additionally, participation in a group fitness setting offers opportunities for socialization. Regular participation in an Essentrics training program may lead to positive physical performance outcomes in older adults, supporting the goal of maintaining independence while continuing to engage actively in the community.

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