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Falls are a major public health concern, especially for older adults. The rate of older adult falls is expected to increase over the next decade. One of the main factors that contributes to falls is a decline in balance. Maintaining balance is important for the safe execution of daily activities. The current fall prevention literature suggests that balance exercise is most effective in reducing falls and fall related injuries. Balance interventions have focused mainly on the biomechanics overlooking behavioral strategies that are related to instructions. A body of literature specific to instructional cues examines attentional focus. Attentional focus has been categorized into an external focus (EF) (directs the performer's attention to the effects of the movement) and an internal focus (IF) (directs the performer's attention to the movement itself). An EF instruction has shown to enhance performance in several different motor tasks and skills. The purpose of this study was to examine the relationship between exercise (duration/intensity) completed outside of a 12-week balance training intervention with EF or IF instructions and postural control (Xsens and Btracks), physical function (FGA, BBS, and TUG), balance confidence (ABC-6), fear of movement (TSK), and quality of life (SF-36) in older adults with elevated fall risk. Change scores were determined by finding the difference between baseline (week 0) and after the balance training (week 12). The hypotheses were: (1) Regardless of group assignment, greater exercise minutes will be significantly associated with greater positive change scores for FGA, BBS, TUG, ABC-6, TSK, and SF-36 and greater negative change scores for postural control, and (2)

Regardless of group assignment, greater vigorous exercise minutes will be significantly associated with greater positive change scores for FGA, BBS, TUG, ABC-6, TSK, and SF-36 and greater negative change scores for postural control, but light exercise and moderate exercise will not.

THE EFFECTS OF PHYSICAL ACTIVITY THROUGHOUT

A 12-WEEK BALANCE INTERVENTION

PROGRAM IN OLDER ADULTS

WITH FALL-RISK

by

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APPROVAL PAGE

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CHAPTER I

INTRODUCTION

Falls are a major public health concern for the older adult population, with more than one third of adults age 65 and older experiencing a fall each year (CDC, 2017). A fall can be defined as an event in which an individual comes to a rest unintentionally on the ground, floor, or another lower level (WHO, 2018). Research consistently reports that falls result in diminished quality of life, negative psychological effects such as fear of falling and reduced confidence (Luthy, Cedraschi, Allaz, Herrmann, & Ludwig, 2015; Sharaf & Ibrahim, 2008; Tinetti & Williams, 1998). The side effect from the negative psychological effects can lead to an increase in sedentary lifestyles (Stenhagen, Ekström, Nordell, & Elmståhl, 2014), contributing to an anticipated increased fall rate in older adults. Therefore, it is important to consider interventions that help individuals maintain functional independence.

Maintaining postural stability is important for both safely executing motor movements that help us remain in balance and for maintaining functional independence (Shumway-Cook, Baldwin, Polissar, & Gruber, 1997). Balance can be categorized into static (maintaining base of support) and dynamic (maintaining balance during movement) balance (Winter, Palta, & Frank, 1990; Karimi & Solomonidis, 2011). We know that most falls occur during dynamic movement (Berg, Alessio, Mills, & Tong 1997; Kelsey, Procter-Gray, Hannan, & Li, 2012; Li et al., 2006; Tinetti, Speechley, & Ginter, 1988), therefore, understanding fall related behavior patterns and offering balance strategies during dynamic movements becomes important. The current literature on fall preventions proposes that exercise specific to balance is effective for reducing fall rate and the injuries associated with falls (Sherrington et al., 2019). Implementing the delivery of effective balance interventions may enhance the efficacy of reducing falls in older adults. The focus of current interventions is specific to the biomechanical aspects of movement, often ignoring behavioral considerations specific to motor learning and control. Recently a body of literature examined the effects of attentional focus partially bridging the gap between motor learning/control and biomechanics, using instructional cues. Further exploration with modifying instructional cues suggested that during the learning period, attention could be directed in two different manners (Wulf, HoB, & Prinz, 1998; Lohse, Wulf, & Lewthwaite, 2012; Marchant, Greig, Bullough, & Hitchen, 2011; Wulf & Lewthwaite, 2010).

Attentional focus is the direction of attention to a specific detail related to the task, movement, or environment (Wulf et al., 1998). Attentional focus can be further categorized into an internal focus (IF) of attention (directing attention to an individual's movement) or an external focus (EF) of attention (directing individuals' attention to the effects of their movements) (Wulf et al., 1998; Wulf, Lauterbach, & Toole, 1999; Wulf, McNevin, & Shea, 2001; McNevin, Shea, & Wulf, 2003; Wulf, Weigelt. Poulter & McNevin, 2003). The literature is consistent that using an EF instruction is more beneficial to motor learning and performance in several balance domains. Chiviacowsky and colleagues wanted to examine whether attentional focus instructions would differentially affect the learning of a balance task in older adults (Chiviacowsky, Wulf, & Wally, 2010). Therefore, participants were asked to stand on a balance platform (stabilometer) tilting to the left and right and to try to keep the stabilometer as close to horizontal as possible with 10 (30 sec.) practice trials with attentional focus instructions on day 1 and a retention test following the next day with 5 (30 sec.) trials without attentional focus instructions. The study observed that the EF group performed better than the IF group in the retention test and that learning benefits of an EF are generalizable to older adults. In contrast, Landers and colleagues wanted to investigate the generalizability of attentional focus to balance in participants with Parkinson's disease (Landers, Wulf, Wallmann, & Guadagnoli, 2005). The participants completed 3 trials of three conditions on the Balance Master force plate (e.g., eyes open- fixed support surface and surround; eyes closed- fixed support surface and surround; eyes open-sway-referenced support surface and fixed surround) with attentional focus instructions (EF, IF, CON) provided prior to each trial. The findings suggest that the balance of participants with Parkinson's disease and a fall history can be enhanced by instructing subjects to adopt an EF. The benefits associated with an EF instruction can be explained through the constrained action hypothesis that suggests using an IF instruction has more conscious control, which results in the automatic control processes to be constrained (Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001; McNevin et al., 2003). In contrast, when an EF is used, the motor system has shown that it can self-organize, this facilitating automaticity (Wulf, Shea, & Park, 2001; Kal, van der Kamp, & Houdijk, 2013; Vidal, Wu, Nakajima, & Becker, 2018). Although, there are several balance interventions that are currently used, they are yet to show consistent results to suggest that they contribute positively to a reduction in falls. In addition, to further exploring the effects of instructional cues on postural stability, we need to consider other factors that individuals maybe participating outside of the intervention, such as physical activity.

Physical activity is beneficial for older adults to maintain a high functioning lifestyle and the ability to be able complete activities of daily living safely. Recently, physical activity has been considered important to improving the functional capacity in older adults (Cadore, Rodríguez-Mañas, Sinclair, & Izquierdo, 2013). Exercise programs designed specifically for the older adult population have been effective. Exercise interventions should aim to reduce the number of falls in the older adult population and improve overall balance (Cadore et al., 2013). Exercise has demonstrated to reduce falls with exercise that includes a high challenge balance activity and greater than 3 hours per week (Sherrington et al., 2017).

A recent systematic review on the effects of exercise on balance in older adults reported on measures of balance specific to daily activities, such as: TUG, BBS, ability to stand on one leg, and walking speed (Howe, Rochester, Neil, Skelton, & Ballinger, 2011). The findings suggested that the most effective programs were 3x a week for three months and included dynamic exercise (Howe, 2011). Another study investigated whether participation in a weekly group exercise program in addition to home exercises over the course of one-year improved balance, muscle strength, reaction time, physical functioning, health status, and prevents falls in at-risk community-dwelling older adults (Barnett, Smith, Lord, Williams, & Baumand, 2003). The results suggested that participation in a weekly group exercise program with home exercises does improve balance and reduce the rate of falls (Barnett et al., 2003).

Further work is needed to better understand if outside exercise during balance training interventions affects physical function and qualitative outcomes. The current study is a secondary data analysis of a R-15 grant directed on attentional focus and a balance training task in relation to fall related outcomes. Attentional focus strategies that are utilized during a balance training intervention will be examined to determine the impact the intensity of exercise completed outside of the intervention in addition to understanding impact of additional exercise on fall risk outcome measures.

The purpose of this study was to examine the relationship between exercise (duration/intensity) completed outside of a 12-week balance training intervention with EF or IF instructions and postural control (Xsens and Btracks), physical function (FGA, BBS, and TUG), balance confidence (ABC-6), fear of movement (TSK), and quality of life (SF-36) in older adults with elevated fall risk. The specific aims and hypotheses for this study are:

Specific Aim 1: Examine the relationship between duration of exercise completed outside of a 12-week balance training intervention and postural control, physical function (e.g. FGA, BBS, and TUG), balance confidence (ABC-6), fear of movement (TSK), and quality of life (SF-36) for the internal and external focus groups.

Hypothesis 1: Regardless of group assignment, greater exercise minutes will be significantly associated with greater positive change scores for FGA, BBS, TUG, ABC-6, TSK, and SF-36 and greater negative change scores for postural control.

Specific Aim 2: Examine the relationship between intensity of exercise completed outside of a 12-week balance training intervention and postural control, physical function (e.g., FGA, BBS, and TUG), balance confidence (ABC-6), fear of movement (TSK), and quality of life (SF-36) for the internal and external focus groups.

Hypothesis 2: Regardless of group assignment, greater vigorous exercise minutes will be significantly associated with greater positive change scores for FGA, BBS, TUG, ABC-6, TSK, and SF-36 and greater negative change scores for postural control, but light exercise and moderate exercise will not.

CHAPTER II

REVIEW OF THE LITERATURE

Falls in the Older Adult Population

Falls are a major public health concern for the older adult population (Tinetti, 2003; Carroll, Slattum, & Cox, 2005; CDC, 2017). More than one out of three older adults ages 65 and older experience a fall each year (CDC, 2017). Falls are one of the primary causes of fatal and nonfatal injuries among the older adult population (Stevens, Mack, Paulozzi, & Ballesteros, 2008; CDC, 2017). Falls are the leading cause of injury related deaths in adults ages 65 and older (Kannus, Parkkari, Niemi, & Palvanen, 2005; CDC, 2020). As adults age, the prevalence of falls increases, resulting in moderate to severe injuries, such as lacerations, hip fractures, head trauma (Stevens, Corso, Finkelstein, & Miller, 2006). Research has shown when injuries occur due to falls, that overall quality of life is impacted primarily due to a reduction in physical activity (Sharaf & Ibrahim, 2008; Bjerk, Brovold, Skelton, & Bergland, 2018). Some of the injuries can increase risk for future falls results in costly hospital and rehabilitation. The strain on the health care system from both an increase in patients and approximately $50 billion/year is spent on medical costs related to non-fatal fall injuries and $754 million/year is spent related to fatal falls (CDC, 2020). Thus, making the demand for a low-cost balance intervention such as a behavioral measure that redirects attentional focus using instructional cues are necessary to contribute to the maintenance of functional independence.

External vs. Internal Focus of Attention

Attentional focus is directing attention to a specific detail related to the task, movement, or environment (Wulf, 2013). It has been categorized as associative (focusing on bodily sensation) or dissociative (blocking out sensations resulting from physical effort), or in terms of width (broad vs. narrow) and direction (interval vs. external) (Morgan, 1978; Weinberg, Smith, Jackson, & Gould, 1984; Moran, 1996; Wulf 2007). An individual's attentional focus has an influence on immediate performance (during practice when instructions are given) and learning (permanent changes in capability to perform a skill), and this can be measured by retention or transfer tests (after a certain period of time or without instructions) (Wulf et al., 2013).

An EF directs the performer's attention to the effects of the movement on the environment, whereas an IF directs the performer's attention to the movement itself (Wulf, McNevin, & Shea, 2001; Wulf, HoB, & Prinz, 1998; Wulf, Laterbach, & Toole, 1999; McNevin, Shea, & Wulf, 2003). Over the past decade, a growing body of research suggests adopting an EF enhances automaticity and effectiveness of movements (Wulf, 2007; Jackson & Holmes, 2011; Chiviacowsky et al., 2010; Landers et al., 2005; Diekfuss, Rhea, Schmitz, Grooms, Wilkins, Slutsky, & Raisbeck (2019). It has been demonstrated that minimal changes in wording during instructions can influence overall performance (Wulf, 2007). The change in instructional cues has been examined and findings have consistently revealed that modifying words to direct attention to either the internal or external aspects of movement can be used to optimize training, performance and learning.

One of the first studies to examine attentional focus investigated the effects of instructional cues on learning (Wulf, HoB, Prinz, 1998). Using a ski-participants were told when to exert force on the platform by focusing on the instructions that they were assigned. Participants in the IF condition were told to focus on their feet, while the EF condition focused on the ski-simulator wheels. The results suggested superior learning and performance for the EF condition. In a follow up experiment, participants were asked to balance on a stabilometer following internal of external instructions. The IF condition focused on their feet and the EF condition focused on keeping the markers on the board in a horizontal position. The results were similar in that showed superior learning and retention for the EF condition. Many studies have investigated the influence of adopting an IF or EF for balance and postural control (Chiviacowsky et al., 2010; Wulf et al., 2003; Landers et al., 2005; McNevin, Weir, & Quinn, 2013). In one study, researchers wanted to examine whether instructions (EF vs. IF) would differentially affect the learning of a balance task in older adults and they found that the EF group performed better than the IF group in the retention test and that learning benefits of an EF are generalizable to older adult (Chiviacowsky et al., 2010). In addition, one study investigated whether the attentional focus induced by a supra-postural task had an influence on the learning of a dynamic balance task and the findings suggested that the performer's attentional focus in regards to the supra-postural task affects performance and learning, not only of the supra-postural task, but also of the postural task (Wulf et al., 2003). Another study examined the generalizability of the attentional focus findings to balance in subjects with Parkinson's disease and they found that balance of subjects with Parkinson's disease and a fall history can be enhanced by instructing subjects to adopt an EF (Landers et al., 2005). Additionally, another study investigated supra-postural task performance (manual tracking) and postural control (sway and frequency) as a function of attentional focus, age, and tracking difficulty and found limited support for EF benefits in a mildly challenging tracking task while older adults tend to adopt a conservative postural control strategy, regardless of tracking task difficulty, EF instructions on a supra-postural task promoted a modest, beneficial shift in postural control (McNevin et al., 2013).

To explain the attentional focus effects, the constrained action hypothesis (CAH) was proposed (Wulf, McNevin, Shea, 2001). This hypothesis suggested that using an IF facilitates conscious control that results in the inhibition of the motor system. Therefore, the use of an IF instruction constrains the automatic control processes of the body. Although, an EF allows more automaticity in the motor system. Through the EF instruction, the motor system can self-organize. It has been suggested that when performers adopt an EF, they can experience the stage of learning faster, which is effective for movement efficiency. The CAH was further explored through a secondary probe reaction time task while performing a stabilometer task (Wulf, McNevin, Shea, 2001). Participants were randomly assigned to an IF or EF condition and asked to balance on a stabilometer as their primary task. For the secondary task, participants were told to respond as quickly as possible to the stimulus that was given by pressing the button in their right hand. Results revealed that probe reaction time for participants no matter the condition was reduced during practice and the EF condition experienced lower reaction times throughout practice and retention. These findings support the presumed suggestions of reduced attention with an EF supporting the CAH.

Balance Training Intervention Studies

Previous interventions have focused mainly on the biomechanical aspects of balance, although often overlooking potential behavioral influences such as refocusing attention (Meyer & Ayalon, 2006). Although interventions exist that are specific to balance, the findings have been inconsistent, and there has not been a sizeable decline in fall rates (Lomas□Vega, Obrero□Gaitán, Molina□Ortega, & Del□Pino□Casado, 2017; Nick, Petramfar, Ghodsbin, Keshavarzi, & Jahanbin, 2016). Interventions specific to rehabilitation have attempted to improve balance by including attentional focus cues (McNevin, Wulf, & Carlson, 2000; Landers, Hatlevig, Davis, Richards, & Rosenlof, 2016; Sherrington et al., 2017). These intervention programs have primarily been short term, thus still leaving the longitudinal effects unknown. The address the lack of longitudinal data, Landers and colleagues examined the effects of attentional focus on balance outcomes in individuals with Parkinson's disease in a community-dwelling setting (Landers et al., 2016). Participants were randomly assigned to one of four groups: balance training + EF instructions, balance training + IF instructions, balance training + no attentional focus instructions, or control). Each condition completed 4 weeks of training with their respective instruction 3 x week for 45 minutes. The intervention conditions completed 10 minutes of treadmill training, 10 minutes of obstacle course negotiation, and 10 minutes of balance training (tandem stance, narrow support stance, single leg stance, eyes closed and external perturbations). The control condition did not participate in training during the intervention. All participants completed testing (Sensory Organization Test, Berg Balance Scale, Self-Selected Gait Velocity, Dynamic Gait Index, and Activities Specific Balance Confidence Scale) prior to training then at 4,6,8, and 12 weeks. The results suggest that attentional focus instructions during a standardized balance training program did not improve balance impairment and balance activity outcomes in participants with Parkinson's disease (Landers et al., 2016). Overall, all groups (A, B, C, and D) demonstrated improved balance performance across most measurements over the course of the outcomes. It was suggested that duration of the balance training was not sufficient to see benefits associated with the training.

Exercise and Older Adults

Physical activity and exercise are terms that are often associated together but describe different concepts. Physical activity is any bodily movement produced by skeletal muscles that results in energy expenditure, which consists of occupational activities and leisure activities, while exercise can be defined as a subset of physical activity that is planned, structured, and repetitive bodily movement (Caspersen, Powell, & Christenson, 1985; DHHS, 2018). Physical activity can be categorized into light, moderate, and vigorous intensity (DHHS, 2018). According to the Centers for Disease Control, older adults should engage in at least 150-minutes to 300-minutes of moderate-intensity aerobic activity a week or 75-minutes to 150-minutes of vigorous-intensity aerobic activity a week, or a combination of both (CDC, 2020). In addition to the CDC recommendations for aerobic and muscle-strengthening activity, it is recommended that older adults engage in multicomponent physical activity that includes balance training, critical for improving physical function and diminishing the risk of fall or injuries from a fall in older adults (Gillespie et al., 2012; Sherrington et al., 2008; Sherrington, Tiedemann, Fairhall, Close, & Lord, 2011; Sherrington et al., 2017). A recent meta-analysis examined the effects of exercise on fall rates specific to the characteristics of the trial design, sample or intervention are associated with greater fall prevention effects. Their findings suggest that future fall prevention programs should include exercise that aims to provide an increased challenge to balance, such as reducing the base of support, moving the center of gravity and controlling body position while standing, and standing without using the arms for support. In addition, the research suggests that at least 3 hours of exercise per week is the most effective (Sherrington et al., 2017).

Physical Function and Qualitative Outcomes

Functional independence is a person's ability to be able to complete activities of daily living (ADLs) (Katz, 1983). The ability to safely navigate ADLs can be diminished as the result of falls in the older population. The self-reported physical function and qualitative outcomes can give a subjective insight to what an individual is experiencing. As a result of participation in a balance training intervention, the results of these outcomes could potentially be positively affected with a simple change in instructional cue delivery (e.g., EF or IF). These patient-reported outcomes can be used to better understand balance and fall-risk in the older adult population.

The Functional Gait Assessment (FGA) is a 10-item gait assessment based on the modified Dynamic Gait Index (DGI). The DGI was developed to assess postural stability during gait tasks in older adults at the risk of falling (Shumway-Cook, 1995). The DGI consisted of 8 tasks, such as walking at different speeds, walking while turning the head, ambulating over and around obstacles, ascending and descending stairs, and making quick turns. Shumway and her colleagues measured the reliability of the DGI using a sample of community-dwelling older adults with a variety of balance abilities (Shumway-Cook, 1995). Interrater reliability (.96) was found using the ratio of subject variability to total variability. Two therapists repeated the test 1 week later to determine test-retest reliability. Again, using the ratio of subject variability to total variability, test-retest reliability was found to be .98 (Shumway-Cook, 1995). The FGA includes 7 out of the 8 tasks from the DGI and 3 new items. The FGA was designed to improve reliability and reduce the ceiling effect (Wrisley, Marchetti, Kuharsky, & Whitney, 2004). The FGA demonstrates comparable reliability to the DGI and is acceptable based on reliability and validity as a clinical gait measure for patients with vestibular disorders (Wrisley et al., 2004).

The Berg Balance Score (BBS) is a 14-item scale that quantitatively assesses balance and fall risk in older community-dwelling adults through observation of their performance (Berg, Wood-Dauphinee, Williams, & Maki, 1992). The BBS assesses static and dynamic balance activities. Scores for this test range from 0 to 56, with higher scores indicating better balance performance. It was determined that the relative intrarater reliability for the BBS was high (ICC=.97) (Conradsson et al., 2007). The BBS is considered a valid measure to evaluate balance in clinical practice.

The Timed-Up and Go (TUG) is a modified version of the Get-Up and Go Test (Mathias, Nayak, & Isaacs, 1986). TUG assess mobility, balance, walking ability and fall risk in the older adult population. Individuals are observed for the time that it takes to rise from an armchair, walk 3 meters, turn around, walk back and return back to the seated position. This test is rather quick to complete and does not require special equipment or training TUG has been found to be reliable and valid test for quantifying functional mobility (Podsiadlo & Richardson, 1991).

Btracks Balance Test (BBT) is used to determine abnormalities in postural sway, which are linked to negative clinical outcomes (Goble & Bawega, 2018). The BBT was designed to overcome the previous limitations of the force plate, such as cost and portability. Therefore, Btracks is more affordable, portable, and uses a user-friendly software that objectively and reliably tests postural sway (Benedict, Hinshaw, Byron-Fields, Baweja, & Goble 2017; Hearn, Levy, Baweja, & Goble, 2018). The BBT is effective in assessing clinical populations because it is fast (<2 mins.), easy to administer, and uses a protocol (4- 20 secs. Trials of standing with eyes closed) that most individuals who are ambulatory can complete without falling (Goble & Baweja, 2018).

Xsens is a 3D motion tracking system that is used to capture joint angular kinematics measurements. This motion tracking system allows human movement to be digitally recorded. Xens sensors have the ability to collect displacement in the medial-lateral (ML) and anterior-posterior (AP) directions (Diekfuss et al., 2019). This motion capture system is cost efficient, completely wireless, and easy to use in a variety of different environments (Schepers, Giuberti, & Bellusci. 2018).

The activities specific balance confidence scale (ABC) is a self-reported measure of confidence with various daily functional tasks that require balance. The ABC-16 is 16-item self-reported measure rating confidence and ranges from 0-100 (0= no confidence and 100= greater confidence). The ABC-6 is a short version designed to assess balance confidence and fear of falling more efficiently due to the time constraints of the ABC-16 in clinical settings (Peretz, Herman, Hausdorff, & Giladi, 2006). The intraclass correlation coefficient between the long (ABC-16) and short version (ABC-6) was 0.88 (Peretz et al., 2006). The ABC-6 was found to be valid as the ABC-16 to assess balance confidence and fear of falling (Peretz et al., 2006).

The Short Form Health Survey (SF-36) is a self-reported measure of an individual's physical abilities with daily life and how they feel mentally and physically. The SF-36 is a 36-item questionnaire that includes eight health concept scores that are the weighted sums of the questions in their respective section. The eight scaled scores are transformed on a 0-100 scale, lower scores indicate more disability and higher scores indicate less disability. The eight health concept scores consist of**:** limitations in physical activities because of health problems; limitations in social activities because of physical or emotional problems; limitations in usual role activities because of physical health problems; bodily pain; general mental health; limitations in usual role activities because of emotional problems; vitality; and general health perceptions (Ware & Sherbourne, 1992).

The Tampa Scale for Kinesiophobia (TSK) is a self-reported survey that assesses the rating of kinesiophobia and fear of movement (Miller & Kori & Todd, 1991). The scale was originally designed to measure the fear of movement related to chronic lower back pain. The scale is 17-items with a 4-point Likert scale and scores ranging from strongly disagree to strongly agree (Miller et al., 1991). Scores range from 17 to 68, where a higher score indicates an increased degree of kinesiophobia,

CHAPTER III

OUTLINE OF PROCEDURES

Participants

Fifty older adults between the ages of 65-90 years were recruited to participate in this study (80.74 ± 6.21 years). To be eligible for participation, all participants must have experienced a fall within the past 12 months, be able to walk for 10 consecutive minutes without an assistive device, have no diagnosed neurological disorder, have better than 20/70 vision, a body mass index of less than 30, and no acute muscle problems that lead to pain or discomfort during standing or walking Prior to participation, participants needed to score equal or greater than 25 on the Mini-Mental State Examination (MMSE) and receive medical clearance. Participants completed an informed consent form approved by the University's institutional review board.

Instrumentation

30" wobble boards (CANDO, New York, USA) were used during the 12-week balance training intervention. Btracks Balance Tracking System (Sports Balance Software) was used for measuring postural sway. Xsens Technology (MA, USA) was used in combination with a 30" wobble board for motion tracking.

Procedures

Participants were randomly assigned to one of the two experimental conditions (EXT-balance training with an external focus, INT- balance training with an internal focus. Participants in the EXT or INT conditions participated in the 12-week balance training program at their respective facility. Prior to starting the balance training program, participants performed baseline fall risk assessments such as: postural control (Xsens and Btracks), physical function (FGA, BBS, and TUG), balance confidence (ABC-6), fear of movement (TSK), and quality of life (SF-36) (see figure 2).

The balance training consisted of 24 sessions, meeting twice weekly for approximately 30 minutes. Each session was broken into a 5-minute warm-up, a 20-minutes of specific balance training, and a 5-minute cool down. The balance training consisted of twenty trials of practice standing on a 30" wobble board for 30-second intervals with a 30-second rest period in between each trial (see figure 1). Prior to each balance practice trial, the EXT condition was told to "please keep the board as level as possible" and the INT condition was told to "keep your feet as level as possible." A compliance check was given to monitor if the EXT and INT condition were focusing as instructed. Participants maintained their normal daily physical activity and completed physical activity logs that were collected at baseline (week 0) and after the balance training (week 12). Following each balance training session, participants in the EXT and INT completed one 30 second balance test on a wobble board fitted with an accelerometer. Following the 12-week training program, participants completed the same fall risk assessments that were collected at baseline (see figure 2).

Data Collection and Analysis

Total Exercise minutes for each week and the type of exercise intensity (i.e., light, moderate, and high) was used for analysis. Change scores were determined by finding the difference between baseline (week 0) and after the balance training (week 12). Statistical analyses were performed using SPSS for Windows (SPSS 26.0; IBM Corp., Armonk, NY, USA) with significance set at an α level of $p < 0.05$. The normal distribution of residuals, linearity, and homogeneity of variance were examined across all combinations of outcome variables. Condition□specific means and standard deviations (mean ± SD) were calculated for all participant characteristics; see Table 1, and independent *t* tests then identified any differences between groups; see Table 2. Partial correlations were calculated to assess the strength of relationships between variables of interest while holding constant condition see Table 3. To test the hypothesis that attentional focus during a balance training intervention moderates the relationship between exercise performed outside of the training intervention and change in fall risk outcomes, a moderation analysis was performed via model 1 of the PROCESS macro for SPSS (Hayes 2013) (see Table 4), total light intensity exercise time (see Table 5), total moderate intensity exercise time (see Table 6), and total vigorous intensity exercise time (see Table 7) as the independent variables, fall risk outcome change scores as the outcome variable, and attentional focus condition as the moderating variable (in the model, IF = 0 and EF =1). Using bootstrapping, 5,000 random samples were taken with replacement to construct 95% bias□corrected bootstrap confidence intervals (CIs).

Figure 1. Participants during balance training intervention

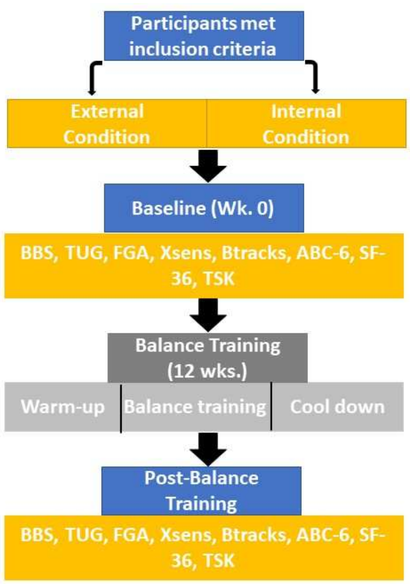

Figure 2. Schematic of Experimental Design

CHAPTER IV

RESULTS

Results

Preliminary analysis – partial correlations

Partial correlations controlling for condition are shown in Table 4. Exercise variables (total exercise time, average exercise light minutes, average exercise moderate minutes, and average exercise vigorous minutes were not related to any fall risk outcome change scores ($p > 0.05$).

Moderation analysis

While partial correlations indicated no significant relationships between exercise variable and fall risk outcomes, Kenny and Judd argue that the standard test of the association between X on Y prior to running a moderation analysis is typically done with less power than are tests of indirect associations of equal size, making them less trustworthy as a deciding factor for future analyses (Kenny & Judd, 2014). Thus, despite the apparent lack of relationship between outcomes, the primary analysis continued as planned because of the theoretical basis of the relationship between exercise and fall risk.

Results of the moderation analyses can be found in Tables 5-8; only significant effects are reported here. For the analysis with total exercise time as the independent variable and SF-36 Physical Role change score as the outcome variable, the interaction between total exercise time and condition was non-significant *b* = 0.012, *t*(40) = 1.939, *p* = 0.060, 95% CI = -0.001, 0.025; however, the conditional effect of condition on change in SF-36 Physical Roll was significant *b* = -60.129, *t*(40) = -2.387, *p* = 0.022, 95% CI = -111.052, -9.206, demonstrating that when total exercise time was equal to zero, greater change in SF-36 Physical Role was observed in the EF condition. Additionally, significant conditional effects, quantifying how much two individuals that differ by one unit on total exercise time in the IF group are estimated to differ on an outcome variable, were observed for change in the standard deviation of acceleration ML *b* = 0.001, *t*(40) = 2.334, *p* = 0.025, 95% CI = 0.000, 0.000, and standard deviation of velocity ML *b* = 0.000, *t*(40) = 2.329, *p* = 0.025, 95% CI = 0.000, 0.000. These results suggest that for the IF condition as total exercise time increased, mean acceleration and mean velocity in in the ML direction during a postural control task increased.

For moderation analyses with average light intensity exercise time as the independent variable and condition as the moderator, significant interactions were observed for the following outcome variables: SF-36 General Health change score *b* = -0.176, *t*(40) = 0.065 , *p* = 0.014, 95% CI = -0.312, -0.040; SF-36 Social Functioning change score t *b* = -0.317, *t*(40) = -4.224, *p* = 0.001, 95% CI = -0.474, -0.159; and TSK *b* = 0.095, *t*(40) = 2.582, *p* = 0.020, 95% CI = 0.017, 0.173. Follow-up analysis of the conditional effects of the focal predictor (light-intensity exercise) at values of the moderator (condition) demonstrated that the effect of average light intensity exercise on change in SF-36 General Health scores was significant for the IF *b* = 0.136, *t*(40) = 2.202, *p* = 0.041, 95% CI = 0.006, 0.265 but not the EF condition *b* = -0.041, *t*(40) = -

2.00, $p = 0.061$, 95% CI = -0.083, 0.002. Similar findings were observed for change in SF-36 Social Functioning scores, with significant effects of average light intensity exercise found for the IF $b = 0.334$, $t(40) = 4.689$, $p < 0.001$, 95% CI = 0.184, 0.484 but not the EF condition $b = 0.017$, $t(40) = 0.738$, $p = 0.470$, 95% CI = -0.032, 0.067. Moreover, the conditional effects of light intensity exercise on change in TSK score was also significant for the IF $b = -0.086$, $t(40) = -2.489$, $p = 0.024$, 95% CI = -0.159, -0.013 but not the EF condition $b = 0.009$, $t(40) = 0.713$, $p = 0.486$, 95% CI = -0.018, 0.036.Additionally, while a significant interaction effect of average light exercise time and condition on change in standard deviation ML was not found $b = -0.024$, $t(40) = -1.650$, $p = 0.115$, 95% CI = -0.055, 0.007, a significant conditional effect of average light exercise time was observed $b = 0.030$, $t(40) = 2.164$, $p = 0.043$, 95% CI = 0.001, 0.058. These finding suggests that for the IF condition as average light intensity exercise time increases, the change in standard deviation ML during a postural control task increases.

The analyses for average moderate intensity exercise time as the independent variable, and condition as the moderator, no significant interactions were observed. However, a significant conditional effects of average moderate intensity exercise time on change in standard deviation acceleration ML $b = 0.003$, $t(40) = 2.351$, $p = 0.024$, 95% CI = 0.000, 0.005, and change in standard deviation velocity ML $b = 0.000$, $t(40) = 2.350$, $p = 0.024$, 95% CI = 0.000, 0.000 were found. Similar to our findings with total exercise time, this suggests that for the IF condition as average moderate intensity exercise time increases change in standard deviation acceleration and velocity in the ML direction during a postural task increases.

The analysis for the average vigorous intensity exercise time as the independent variable, a significant interaction effect of average vigorous intensity exercise time and condition was observed for TSK $b = -0.086$, $t(40) = -2.119$, $p = 0.043$, 95% CI = -0.169, -0.003. Follow-up analysis demonstrated that the effect of average high intensity exercise on change in TSK score was significant for the IF $b = -0.086$, $t(40) = -2.489$, $p = 0.024$, 95% CI = -0.194, -0.013 but not the EF condition $b = 0.009$, $t(40) = 0.713$, $p = 0.486$, 95% CI = -0.018, 0.036. Additionally, significant conditional effects of condition on change in mean deviation AP $b = 3.065$, $t(40) = 2.172$, $p = 0.038$, 95% CI = 0.179, 5.952, change in mean acceleration ML $b = 0.535$, $t(40) = 2.249$, $p = 0.032$, 95% CI = 0.049, 1.022, and on change in mean velocity ML $b = 0.009$, $t(40) = 2.257$, $p = 0.032$ 95% CI = 0.001, 0.017 were observed, demonstrating that when average high intensity exercise time was equal to zero, the EF condition exhibited.

Table 1. Participant Characteristics

Group	N	Male	Female	Age (yrs.)	Height (cm)	Weight (kg)
IF + EF	50	16	34	80.74(6.21)	165.46(10.6)	69.73(14.71)
IF	22	9	13	80.95(6.41)	164.80(12.33)	69.96(17.21)
EF	28	7	21	80.57(6.16)	165.98(9.22)	69.55(12.74)

Note. Values are reported as [mean (SD)], EF = External Focus, IF= Internal Focus

Table 2. Independent T-Test for Group Differences	Condition	Mean	Std. Deviation	t-test for Equality of Means (sig 2-tailed)
Total Exercise Minutes	IF	3164.090	1832.846	0.978
	EF	3180.610	2240.944	0.977
Average Exercise Light	IF	51.349	48.681	0.406
	EF	85.308	124.938	0.380
Average Exercise Moderate	IF	152.951	144.560	0.716
	EF	167.963	141.616	0.717
Average Exercise Vigorous	IF	94.870	139.692	0.618
	EF	76.721	72.353	0.642
ABC-6	IF	1.280	16.309	0.223
	EF	7.262	17.502	0.219
SF36_PF	IF	5.000	13.346	0.357
	EF	1.482	11.420	0.376
SF36_PR	IF	26.471	43.724	0.164
	EF	8.333	39.831	0.175
SF36_BP	IF	-0.588	13.087	0.950
	EF	-0.852	13.595	0.949
SF36_GH	IF	-1.765	8.385	0.134
	EF	2.333	8.845	0.131
SF36_V	IF	0.000	6.614	0.404
	EF	2.778	12.506	0.343
SF36_SF	IF	0.735	14.300	0.478
	EF	-2.778	16.747	0.463
SF36_ER	IF	5.882	21.198	0.313
	EF	-2.469	29.127	0.279
SF36_MH	IF	2.588	3.447	0.973
	EF	2.519	8.011	0.968
TSK	IF	-1.500	8.376	0.754
	EF	-2.260	7.430	0.756
Berg	IF	0.450	3.648	0.577
	EF	1.210	5.453	0.559
Tug	IF	-0.856	1.882	0.319
	EF	-0.120	2.994	0.294
FGA	IF	1.410	2.987	0.562
	EF	1.960	3.585	0.553
Btracks	IF	1.500	16.463	0.866

	EF	2.210	13.251	0.869
TimeinBalance_AP	IF	0.783	10.425	0.509
	EF	-1.224	10.213	0.510
TimeinBalance_ML	IF	0.539	6.838	0.734
	EF	1.531	11.975	0.725
MeanDev_AP	IF	-0.570	2.753	0.343
	EF	0.254	3.092	0.339
StdDev_AP	IF	0.447	2.268	0.442
	EF	-0.103	2.552	0.438
MeanDev_ML	IF	0.134	2.310	0.207
	EF	-0.653	1.901	0.213
StdDev_ML	IF	-0.073	2.540	0.528
	EF	-0.567	2.755	0.526
MeanAcc_AP	IF	-0.005	0.391	0.498
	EF	-0.082	0.376	0.499
StdAcc_AP	IF	0.056	0.397	0.327
	EF	-0.035	0.218	0.346
MeanAcc_ML	IF	-0.157	0.531	0.136
	EF	0.074	0.509	0.138
StdAcc_ML	IF	0.222	1.113	0.249
	EF	-0.047	0.295	0.281
MeanVel_AP	IF	0.007	0.148	0.939
	EF	0.010	0.101	0.940
StdVel_AP	IF	-0.004	0.148	0.987
	EF	-0.003	0.107	0.987
MeanVel_ML	IF	-0.003	0.009	0.133
	EF	0.001	0.008	0.135
StdVel_ML	IF	0.004	0.019	0.255
	EF	-0.001	0.005	0.287
MPF_Roll	IF	0.052	0.213	0.856
	EF	0.042	0.170	0.858
MPF_Pitch	IF	0.019	0.142	0.460
	EF	-0.010	0.129	0.463

Note. ABC-6 = Activities Specific Balance Confidence Scale, SF-36 _PF = Short Form Health Survey Physical Functioning, SF-36 _PR = Short Form Health Survey Physical Role, SF-36 _BP = Short Form Health Survey Bodily Pain, SF-36 _GH = Short Form Health Survey General Health, SF-36 _V = Short Form Health Survey Vitality, SF-36 _SF = Short Form Health Survey Social Role, SF-36 _ER = Short Form Health Survey Emotional Role, SF-36 _MH = Short Form Health Survey Mental Health, TSK = Tampa Scale Kinesiophobia, Berg = Berg Balance Scale, TUG= Timed Up and Go, FGA = Functional Gait Assessment, AP = Anterior-Posterior, ML = Medial Lateral, MeanDev= Mean Deviation, StdDev = Standard Deviation, MeanAcc = Mean Acceleration, StdAcc = Standard Acceleration, MeanVel = Mean Velocity, StdVel = Standard Velocity, MPF = Mean Power Frequency

Table 3. Partial correlations of relationships between variables of interest while holding constant condition

	Total Exercise Minutes		Average Exercise Light Minutes		Average Exercise Moderate Minutes		Average Exercise Vigorous Minutes	
	Correlation	*p*	Correlation	*p*	Correlation	*p*	Correlation	*p*
ABC-6	0.428	0.111	0.275	0.321	0.128	0.650	0.465	0.081
SF36_PF	0.355	0.195	0.242	0.384	0.264	0.342	-0.185	0.510
SF36_PR	-0.118	0.675	0.085	0.762	-0.120	0.671	-0.078	0.782
SF36_BP	-0.326	0.236	-0.015	0.956	-0.223	0.424	-0.282	0.309
SF36_GH	-0.410	0.129	-0.091	0.748	-0.492	0.063	0.260	0.349
SF36_V	0.133	0.636	-0.099	0.725	0.093	0.741	0.192	0.493
SF36_SF	-0.021	0.941	0.238	0.392	-0.126	0.656	-0.062	0.826
SF36_ER	-0.049	0.862	-0.085	0.764	-0.197	0.481	0.483	0.068
SF36_MH	-0.018	0.950	-0.059	0.833	-0.109	0.700	0.248	0.374
TSK	0.103	0.716	-0.077	0.784	0.256	0.356	-0.311	0.259
Berg	-0.104	0.713	0.378	0.165	-0.226	0.418	-0.009	0.973
Tug	-0.062	0.827	-0.122	0.665	-0.087	0.759	0.160	0.569
FGA	0.424	0.116	-0.035	0.902	0.312	0.258	0.349	0.202
Btracks	0.123	0.662	0.400	0.140	-0.029	0.918	-0.036	0.900
TimeinBalance_AP	0.090	0.750	-0.331	0.227	0.134	0.635	0.325	0.238

TimeinBalance_ML	-0.355	0.194	-0.497	0.059	-0.102	0.719	-0.045	0.873
MeanDev_AP	-0.118	0.676	0.028	0.922	-0.054	0.849	-0.229	0.413
StdDev_AP	0.180	0.520	0.049	0.864	0.119	0.673	0.028	0.922
MeanDev_ML	0.410	0.129	0.058	0.839	0.232	0.406	0.369	0.176
StdDev_ML	0.321	0.244	0.332	0.226	0.061	0.828	0.170	0.545
MeanAcc_AP	0.311	0.259	0.028	0.921	0.148	0.599	0.402	0.137
StdAcc_AP	0.282	0.308	-0.030	0.916	0.226	0.419	0.078	0.782
MeanAcc_ML	-0.116	0.681	0.069	0.807	-0.089	0.752	-0.194	0.489
StdAcc_ML	0.273	0.324	-0.101	0.720	0.308	0.264	-0.092	0.746
MeanVel_AP	0.008	0.977	0.014	0.961	-0.073	0.796	0.125	0.656
StdVel_AP	0.007	0.980	0.042	0.882	-0.089	0.754	0.132	0.640
MeanVel_ML	-0.115	0.682	0.067	0.811	-0.087	0.758	-0.195	0.487
StdVel_ML	0.273	0.326	-0.102	0.717	0.309	0.263	-0.092	0.744
MPF_Roll	0.113	0.689	-0.169	0.548	0.071	0.802	0.301	0.276
MPF_Pitch	-0.460	0.084	-0.147	0.600	-0.341	0.214	-0.033	0.906

Note. ABC-6 = Activities Specific Balance Confidence Scale, SF-36 _PF = Short Form Health Survey Physical Functioning, SF-36 _PR = Short Form Health Survey Physical Role, SF-36 _BP = Short Form Health Survey Bodily Pain, SF-36 _GH = Short Form Health Survey General Health, SF-36 _V = Short Form Health Survey Vitality, SF-36 _SF = Short Form Health Survey Social Role, SF-36 _ER = Short Form Health Survey Emotional Role, SF-36 _MH = Short Form Health Survey Mental Health, TSK = Tampa Scale Kinesiophobia, Berg = Berg Balance Scale, TUG= Timed Up and Go, FGA = Functional Gait Assessment, AP = Anterior-Posterior, ML = Medial Lateral, MeanDev= Mean Deviation, StdDev = Standard Deviation, MeanAcc = Mean Acceleration, StdAcc = Standard Acceleration, MeanVel = Mean Velocity, StdVel = Standard Velocity, MPF = Mean Power Frequency

Table 4. Moderation Analysis with Total Exercise Minutes

*Moderator = Condition (IF = 0, EF = 1)

					CI95	
X Variables		Coeff	Std.Err.	*p*	LL	UL
ABC-6		-0.001	0.003	0.669	-0.006	0.004
SF36_PF		0.002	0.002	0.330	-0.002	0.006
	Exercise	-0.007	0.005	0.214	-0.017	0.004
	Con	**-60.129**	**25.196**	**0.022**	**-111.052**	**-9.206**
SF36_PR	Int	0.012	0.006	0.060	-0.001	0.025
SF36_BP		-0.002	0.002	0.391	-0.006	0.003
SF36_GH		0.000	0.001	0.848	-0.003	0.003
SF36_V		0.000	0.002	0.981	-0.004	0.003

SF36_SF		0.000	0.003	0.920	-0.005	0.005
SF36_ER		0.003	0.004	0.941	-0.008	0.009
SF_MH		-0.001	0.001	0.941	-0.002	0.002
TSK		0.000	0.001	0.746	-0.002	0.003
Berg		0.000	0.001	0.531	-0.001	0.002
Tug		0.000	0.000	0.660	-0.001	0.001
FGA		0.001	0.001	0.174	0.000	0.002
Btracks		-0.001	0.002	0.829	-0.005	0.004
TimeinBalance_AP		0.001	0.002	0.467	-0.002	0.004
TimeinBalance_ML		-0.002	0.001	0.143	-0.005	0.001
MeanDev_AP		0.000	0.000	0.571	-0.001	0.001
StdDev_AP		0.000	0.000	0.477	-0.001	0.001
MeanDev_ML		0.000	0.000	0.255	0.000	0.001
StdDevML		0.000	0.000	0.930	-0.001	0.001
MeanAcc_AP		0.000	0.000	0.176	0.000	0.000
StdAcc_AP		0.000	0.000	0.258	0.000	0.000
MeanAcc_ML		0.000	0.000	0.379	0.000	0.000
	Exercise	**0.000**	**0.000**	**0.024**	**0.000**	**0.000**
	Con	0.348	0.421	0.413	-0.501	1.197
StdAcc_ML	Int	0.000	0.000	0.090	0.000	0.000
MeanVel_AP		0.000	0.000	0.616	0.000	0.000
StdVel_AP		0.000	0.000	0.546	0.000	0.000
MeanVel_ML		0.000	0.000	0.377	0.000	0.000
	Exercise	**0.000**	**0.000**	**0.025**	**0.000**	**0.000**
	Con	0.006	0.007	0.411	-0.008	0.020
StdVel_ML	Int	0.000	0.000	0.091	0.000	0.000
MPF_Roll		0.000	0.000	0.854	0.000	0.000
MPF_Pitch		0.000	0.000	0.643	0.000	0.000

Note. ABC-6 = Activities Specific Balance Confidence Scale, SF-36 _PF = Short Form Health Survey Physical Functioning, SF-36 _PR = Short Form Health Survey Physical Role, SF-36 _BP = Short Form Health Survey Bodily Pain, SF-36 _GH = Short Form Health Survey General Health, SF-36 _V = Short Form Health Survey Vitality, SF-36 _SF = Short Form Health Survey Social Role, SF-36 _ER = Short Form Health Survey Emotional Role, SF-36 _MH = Short Form Health Survey Mental Health, TSK = Tampa Scale Kinesiophobia, Berg = Berg Balance Scale, TUG= Timed Up and Go, FGA = Functional Gait Assessment, AP = Anterior-Posterior, ML = Medial Lateral, MeanDev= Mean Deviation, StdDev = Standard Deviation, MeanAcc = Mean Acceleration, StdAcc = Standard Acceleration, MeanVel = Mean Velocity, StdVel = Standard Velocity, MPF = Mean Power Frequency

Table 5. Moderation Analysis with Average Light Intensity Exercise Time
*Moderator = Condition (IF = 0, EF = 1)

X Variables		Coeff	Std.Err.	*p*	CI95 LL	CI95 UL
ABC-6	Int	-0.015	0.099	0.880	-0.221	0.190
SF36_PF	Int	0.013	0.115	0.908	-0.228	0.255
SF36_PR	Int	-0.106	0.394	0.791	-0.935	0.722
SF36_BP	Int	-0.228	0.115	0.062	-0.469	0.013
	Exercise	0.136	0.062	0.041	0.006	0.265
	Con	15.883	4.969	0.005	5.443	26.322
SF36_GH	**Int**	**-0.176**	**0.065**	**0.014**	**-0.312**	**-0.040**
SF36_V	Int	0.053	0.109	0.634	-0.176	0.282
	Exercise	0.334	0.071	0.000	0.184	0.484
	Con	16.393	5.750	0.011	4.312	28.474
SF36_SF	**Int**	**-0.317**	**0.075**	**0.001**	**-0.474**	**-0.159**
SF36_ER	Int	-0.223	0.188	0.230	-0.627	0.161
SF_MH	Int	0.002	0.048	0.968	-0.097	0.104
	Exercise	-0.086	0.035	0.024	-0.159	-0.013
	Con	-4.470	3.269	0.190	-11.401	2.460
TSK	**Int**	**0.095**	**0.037**	**0.020**	**0.017**	**0.173**
Berg	Int	0.006	0.021	0.784	-0.038	0.050
Tug	Int	-0.027	0.020	0.195	-0.070	0.015
FGA	Int	-0.008	0.024	0.734	-0.058	0.042
Btracks	Int	0.003	0.104	0.975	-0.214	0.221
TimeinBalance_AP	Int	0.012	0.051	0.812	-0.095	0.120
TimeinBalance_ML	Int	-0.069	0.045	0.144	-0.164	0.026
MeanDev_AP	Int	-0.007	0.016	0.679	-0.041	0.027
StdDev_AP	Int	-0.018	0.014	0.231	-0.047	0.012
MeanDev_ML	Int	0.020	0.013	0.136	-0.007	0.047
	Exercise	**0.030**	**0.014**	**0.043**	**0.001**	**0.058**
	Con	-0.191	1.216	0.877	-2.735	2.354
StdDev_ML	Int	-0.024	0.015	0.115	-0.055	0.007
MeanAcc_AP	Int	0.004	0.002	0.104	-0.001	0.008
StdAcc_AP	Int	0.000	0.003	0.983	-0.006	0.006

MeanAcc_ML	Int	-0.001	0.003	0.705	-0.007	0.005
StdAcc_ML	Int	0.007	0.007	0.342	-0.008	0.023
MeanVel_AP	Int	-0.001	0.001	0.138	-0.002	0.000
StdVel_AP	Int	-0.001	0.001	0.191	-0.002	0.001
MeanVel_ML	Int	0.000	0.000	0.714	0.000	0.000
StdVel_ML	Int	0.000	0.000	0.337	0.000	0.000
MPF_Roll	Int	-0.001	0.001	0.167	-0.003	0.001
MPF_Pitch	Int	-0.001	0.001	0.458	-0.003	0.001

Note. ABC-6 = Activities Specific Balance Confidence Scale, SF-36 _PF = Short Form Health Survey Physical Functioning, SF-36 _PR = Short Form Health Survey Physical Role, SF-36 _BP = Short Form Health Survey Bodily Pain, SF-36 _GH = Short Form Health Survey General Health, SF-36 _V = Short Form Health Survey Vitality, SF-36 _SF = Short Form Health Survey Social Role, SF-36 _ER = Short Form Health Survey Emotional Role, SF-36 _MH = Short Form Health Survey Mental Health, TSK = Tampa Scale Kinesiophobia, Berg = Berg Balance Scale, TUG= Timed Up and Go, FGA = Functional Gait Assessment, AP = Anterior-Posterior, ML = Medial Lateral, MeanDev= Mean Deviation, StdDev = Standard Deviation, MeanAcc = Mean Acceleration, StdAcc = Standard Acceleration, MeanVel = Mean Velocity, StdVel = Standard Velocity, MPF = Mean Power Frequency

Table 6. Moderation Analysis with Average Moderate Intensity Exercise Time

*Moderator = Condition (IF = 0, EF = 1)

					CI95	
X Variables		Coeff	Std.Err.	*p*	LL	UL
ABC-6	Int	-0.014	0.035	0.681	-0.084	0.056
SF36_PF	Int	0.035	0.026	0.186	-0.018	0.088
SF36_PR	Int	0.120	0.089	0.186	-0.060	0.300
SF36_BP	Int	-0.001	0.030	0.986	-0.061	0.060
SF36_GH	Int	0.028	0.017	0.118	-0.007	0.062
SF3_V	Int	-0.017	0.023	0.467	-0.065	0.030
SF36_SF	Int	-0.031	0.030	0.313	-0.092	0.030
SF36_ER	Int	-0.004	0.058	0.952	-0.121	0.114
SF_MH	Int	0.009	0.014	0.551	-0.020	0.038
TSK	Int	0.012	0.018	0.488	-0.024	0.048
Berg	Int	-0.001	0.010	0.892	-0.021	0.019
Tug	Int	0.002	0.005	0.723	-0.009	0.013
FGA	Int	0.009	0.007	0.201	-0.005	0.022
Btracks	Int	-0.016	0.031	0.614	-0.078	0.047
TimeinBalance_AP	Int	0.025	0.022	0.250	-0.018	0.068
TimeinBalance_ML	Int	-0.015	0.019	0.450	-0.054	0.024
MeanDev_AP	Int	-0.004	0.006	0.528	-0.016	0.009
StdDev_AP	Int	-0.001	0.005	0.783	-0.012	0.009
MeanDev_ML	Int	0.003	0.004	0.531	-0.006	0.011
StdDev_ML	Int	-0.004	0.005	0.486	-0.015	0.007
MeanAcc_AP	Int	0.001	0.001	0.366	-0.001	0.002
StdAcc_AP	Int	-0.001	0.001	0.125	-0.002	0.000
MeanAcc_ML	Int	-0.001	0.001	0.473	-0.003	0.001
	Exercise	**0.003**	**0.001**	**0.024**	**0.000**	**0.005**
	Con	0.205	0.339	0.549	-0.480	0.889
StdAcc_ML	Int	-0.003	0.002	0.073	-0.006	0.000
MeanVel_AP	Int	0.000	0.000	0.954	-0.001	0.001
StdVel_AP	Int	0.000	0.000	0.859	-0.001	0.001
MeanVel_ML	Int	0.000	0.000	0.474	0.000	0.000

	Exercise	**0.000**	**0.000**	**0.024**	**0.000**	**0.000**
	Con	0.004	0.006	0.544	-0.008	0.015
StdVel_ML	Int	0.000	0.000	0.073	0.000	0.000
MPF_Roll	Int	0.000	0.000	0.945	-0.001	0.001
MPF_Pitch	Int	0.000	0.000	0.815	-0.001	0.001

Note. ABC-6 = Activities Specific Balance Confidence Scale, SF-36 _PF = Short Form Health Survey Physical Functioning, SF-36 _PR = Short Form Health Survey Physical Role, SF-36 _BP = Short Form Health Survey Bodily Pain, SF-36 _GH = Short Form Health Survey General Health, SF-36 _V = Short Form Health Survey Vitality, SF-36 _SF = Short Form Health Survey Social Role, SF-36 _ER = Short Form Health Survey Emotional Role, SF-36 _MH = Short Form Health Survey Mental Health, TSK = Tampa Scale Kinesiophobia, Berg = Berg Balance Scale, TUG= Timed Up and Go, FGA = Functional Gait Assessment, AP = Anterior-Posterior, ML = Medial Lateral, MeanDev= Mean Deviation, StdDev = Standard Deviation, MeanAcc = Mean Acceleration, StdAcc = Standard Acceleration, MeanVel = Mean Velocity, StdVel = Standard Velocity, MPF = Mean Power Frequency

Table 7. Moderation Analysis with Average Vigorous Intensity Exercise Time
*Moderator = Condition (IF = 0, EF = 1)

					CI95	
X Variables		Coeff	Std.Err.	*p*	LL	UL
ABC-6	Int	0.008	0.058	0.888	-0.110	0.126
SF36_PF	Int	-0.024	0.050	0.642	-0.127	0.079
SF36_PR	Int	0.040	0.174	0.819	-0.316	0.397

SF36_BP	Int	-0.017	0.055	0.762	-0.129	0.096
SF36_GH	Int	0.026	0.030	0.380	-0.034	0.087
SF3_V	Int	0.046	0.042	0.284	-0.040	0.132
SF36_SF	Int	0.024	0.046	0.612	-0.071	0.118
SF36_ER	Int	0.062	0.100	0.542	-0.143	0.267
SF_MH	Int	0.002	0.023	0.948	-0.046	0.049
	Exercise	0.047	0.033	0.171	-0.021	0.115
	Con	3.038	3.643	0.412	-4.425	10.500
TSK	**Int**	**-0.086**	**0.041**	**0.043**	**-0.169**	**-0.003**
Berg	Int	0.014	0.017	0.410	-0.020	0.049
Tug	Int	0.012	0.009	0.206	-0.007	0.031
FGA	Int	0.009	0.013	0.497	-0.018	0.036
Btracks	Int	-0.073	0.045	0.120	-0.165	0.020
TimeinBalance_AP	Int	0.017	0.031	0.601	-0.048	0.081
TimeinBalance_ML	Int	-0.060	0.038	0.124	-0.136	0.017
	Exercise	-0.001	0.006	0.918	-0.012	0.011
	Con	**3.065**	**1.411**	**0.038**	**0.179**	**5.952**
MeanDev_AP	Int	-0.020	0.011	0.086	-0.043	0.003
StdDev_AP	Int	0.005	0.010	0.625	-0.015	0.024
MeanDev_ML	Int	0.010	0.008	0.256	-0.007	0.027
StdDev_ML	Int	0.011	0.009	0.264	-0.009	0.030
MeanAcc_AP	Int	0.002	0.001	0.130	-0.001	0.005
StdAcc_AP	Int	0.001	0.001	0.301	-0.001	0.004
	Exercise	0.000	0.001	0.938	-0.002	0.002

	Con	**0.535**	**0.238**	**0.032**	**0.049**	**1.022**
MeanAcc_ML	Int	-0.003	0.002	0.127	-0.007	0.001
StdAcc_ML	Int	0.002	0.003	0.489	-0.005	0.009
MeanVel_AP	Int	0.000	0.000	0.347	0.000	0.001
StdVel_AP	Int	0.000	0.000	0.782	-0.001	0.001
	Exercise	0.000	0.000	0.942	0.000	0.000
	Con	**0.009**	**0.004**	**0.032**	**0.001**	**0.017**
MeanVel_ML	Int	0.000	0.000	0.126	0.000	0.000
StdVel_ML	Int	0.000	0.000	0.492	0.000	0.000
MPF_Roll	Int	0.001	0.001	0.065	0.000	0.002
MPF_Pitch	Int	0.000	0.001	0.946	-0.001	0.001

Note. ABC-6 = Activities Specific Balance Confidence Scale, SF-36 _PF = Short Form Health Survey Physical Functioning, SF-36 _PR = Short Form Health Survey Physical Role, SF-36 _BP = Short Form Health Survey Bodily Pain, SF-36 _GH = Short Form Health Survey General Health, SF-36 _V = Short Form Health Survey Vitality, SF-36 _SF = Short Form Health Survey Social Role, SF-36 _ER = Short Form Health Survey Emotional Role, SF-36 _MH = Short Form Health Survey Mental Health, TSK = Tampa Scale Kinesiophobia, Berg = Berg Balance Scale, TUG= Timed Up and Go, FGA = Functional Gait Assessment, AP = Anterior-Posterior, ML = Medial Lateral, MeanDev= Mean Deviation, StdDev = Standard Deviation, MeanAcc = Mean Acceleration, StdAcc = Standard Acceleration, MeanVel = Mean Velocity, StdVel = Standard Velocity, MPF = Mean Power Frequency

CHAPTER V

DISCUSSION

This study examined the relationship between exercise (duration/intensity) completed outside of a 12-week balance training intervention with EF or IF instructions and fall risk outcomes (postural control [Xsens and Btracks], physical function [FGA, BBS, and TUG], balance confidence [ABC-6], fear of movement [TSK], and quality of life [SF-36]) in older adults with elevated fall risk.

For the first hypothesis, we proposed that regardless of group assignment, greater exercise minutes would be significantly associated with greater positive change scores for FGA, BBS, TUG, ABC-6, TSK, and SF-36 and greater negative change scores for postural control (Xsens and Btracks). However, our observations were different than expected. Specifically, we observed that as total exercise time increased, change in mean velocity and standard deviation acceleration in the ML direction (as measured by Xsens) during the wobble board task increased for the IF group only. An increase in mean velocity and standard deviation acceleration (identified by a positive change scores) is considered unfavorable as it represents a decline in neuromotor control function needed for maintaining upright stance (Baloh et al. 1998, Davids et al, 1999, and Le Lair & Riach, 1996). Thus, the increased change in mean velocity and acceleration when the IF group controlled the wobble board during the postural task suggests a decline in neuromotor control following the training intervention. Furthermore, for the EF group, when total exercise time was equal to zero, a greater change in SF-36 Physical Role was observed. The Physical Role component score represents limitations in usual activities because of physical health problems, and a positive change score represents an increase in activity limitations. These finding suggest that with no exercise, participants in the EF group reported greater reductions in physical role at the completion of the balance training intervention. Our findings support previous literature regarding the relationship between exercise and physical function. The literature supports that engaging in physical activity can contribute to maintaining quality of life, health, physical function, and reducing falls in older adults (Gillespie et al., 2012; El-Khoury, Cassou, Charles, & Dargent-Molina, 2013; Tricco et al., 2017).

For the second hypothesis, we proposed that regardless of group assignment, greater vigorous exercise minutes will be significantly associated with greater positive change scores for FGA, BBS, TUG, ABC-6, TSK, and SF-36 and greater negative change scores for postural control (Xsens and Btracks), but light exercise and moderate exercise will not. With regard to the IF group and exercise intensity, we observed that as average light and high intensity exercise increased for the IF group, change in TSK scores significantly decreased. This suggests that for the IF group greater time spent doing light and high intensity exercise significantly decreased fear of movement. Additionally, as average light intensity exercise increased for the IF group, change in SF-36 General Health and SF-36 Social Functioning significantly increased for the IF group. This suggests that for the IF group, as average time spent doing light intensity physical activity increased, general health and social functioning improved. Conversely, for the IF group, as average moderate intensity exercise time increased, mean velocity and change in mean acceleration in the ML direction during the wobble board task increased. As described above, a positive change in velocity during a postural control task represents a decline in neuromotor control. With regard to the EF group and exercise intensity, we observed that for the EF group when high intensity exercise was equal to zero, mean deviation AP, as well as mean acceleration ML and standard deviation velocity AP significantly increased. This suggests that neuromotor control declines over the 12-week balance training intervention in participants in the EF group who did not engage in high intensity exercise.

In the regards to the attentional focus paradigm, during the balance training intervention with the wobble board task, participants received EF and IF instructions. It is likely that the robust EF/IF paradigm relationship would be observed for the wobble board measurements (Xsens). For the EF group, neuromotor control only significantly decreased when vigorous intensity exercise time was equal to zero. Thus, for the IF group, even with an increase in total exercise time and average moderate intensity exercise time, postural control declined during the balance training intervention. This suggests that exercise above and beyond the total exercise time one participates in, attentional focus during balance training impacts postural control, with IF having detrimental effects. This is consistent with previous literature in the EF/IF paradigm (Wulf et al., 2003; McNevin et al., 2013; Chiviacowsky et al., 2010). However, our results also suggest that engaging in exercise, particularly vigorous intensity is important, as an EF instruction during a balance training intervention cannot overcome lack of functional capacity.

Previous findings have shown that exercise including a high challenge balance task and exercise that is greater than 3 hours per week can help to reduce falls in the older adult population (Sherrington et al., 2017). Our study is the first to link attentional focus to improving balance in older adults to address fall-risk.

This study is not without limitation. First, it is limited by the self-reported data from participants on a weekly physical activity log (duration and minutes). With self-reported data, there are several biases that must be accounted for such as, exaggerating reporting, under reporting or no reporting. Although self-reported data is commonly used, economical, and easy to collect, it is not always the most reliable. Second, while participants were instructed on attentional foci to use during the training intervention, in alignment with previous literature, instructions were not provided during testing sessions for the wobble board outcomes (Xsens). Additionally, participants were not asked to report the foci used during the test. Thus, while unlikely, it is probable that participants could have employed an opposing focus to their group assignment during testing.

Future directions for this study should address the public health concern of fall risk in older adults by implementing fall prevention interventions that combine exercise and balance training. Fall prevention interventions are important for reducing the number of injuries in older adults, decreasing the fear of falling, and improving overall quality of life. In addition, fall prevention interventions should include attentional focus instructions. The use of instructional cues with the combination of exercise and balance training can be effective in reducing falls in the older adults.

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