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Original Research Article

Acute Effects of a Dynamic Warm-Up and Self-Paced Walking on Functional Balance in Middle-Aged and Older Adults

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Abstract

Introduction: Given 30% of American adults fall annually, and considering the negative physical, psychological, and financial consequences of falling, research must be devoted to improving functional balance to decrease fall risk in middle-aged to older adults. No current literature compares the immediate effects of dynamic warm-up versus self-paced walking on functional balance in adults aged 45 years and above who are participating in a structured exercise program. The purpose of this study was to examine the acute impact of a 15-minute dynamic warm-up vs. self-paced walking intervention on the functional balance of exercise-accustomed individuals aged ≥ 45 years, males and females. **Methods:** Sixteen participants (ten males and six females, aged 68.06 ± 4.50 years) completed three 45-minute sessions. On two days, participants completed either a dynamic warm-up or self-paced walking intervention. A counterbalanced testing design was used; all participants engaged in both interventions. Functional balance scores using The Brief BESTest were collected pre and posttest for each session. **Results:** Two-way repeated measures analysis of variance indicated there was no significant interaction (p<.05) between Warm-up Type (dynamic vs. self-pace walking) and Time (pre- vs. posttests). More specifically, marginal means of balance scores for Dynamic Warm-up was significantly greater than those of Self-paced Walking despite the counterbalanced order of interventions across participants. **Conclusions:** The findings of this study suggest that neither a 15-minute dynamic warm-up nor self-paced walking induce an immediate improvement in the functional balance of middle-aged to older adults. Similar intervention may be implemented in the non-exercising aging adults, and a more sensitive instrumentation is necessary to track the immediate changes in functional balance.

Key Words: Dynamic Warm-Up, Fall Risk, Functional Balance, Middle-Aged Adults, Self-Paced Walking, Older Adults.

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Introduction

Each year, over 30% of American adults over the age of 65 fall[1]. It has been reported that 37.3 million of these aforementioned falls of older adults require health care and 424,000 are fatal[2]. Risk factors associated with falls include medication usage, fear of falling, decreased physical activity and balance, inability to perform activities of daily living (ADLs), decreased gait speed, loss of muscle strength, and dependence on mobility aids[3,4,5,6,2]. Consequences associated with falls include physical, psychological, and financial entities. Terroso et al. (2014) found common physical consequences include fractures, bruises, injuries (lacerations, sprains, increased pain), and other physiological effects (functional decline, mortality)[2]. Additionally, Chen et al. (2021) found that brain trauma and hip fractures are frequent, with hip fractures causing 46% of death among elderly individuals[7]. Psychological consequences include increased fear of falling, depression, anxiety, mortality, morbidity, and premature institutionalization[4].In terms of the financial burden associated with falls, Florence et al. (2018) states that in 2015, $50 billion were spent between fatal and non-fatal falls[1]. Medicare contributed about $28.9 billion for non-fatal falls, Medicaid contributed about $8.7 billion, and private/other payers contributed $12 billion. With one in three adults falling annually, an increasing number of middle to older aged adults (≥45 years old), and negative physical, psychological, and financial consequences of falling, it is imperative that research is devoted to improving functional balance (FB) and decreasing fall risk (FR) in middle to older aged adults[2]. Specifically, research on acute changes in FB is needed to recommend daily interventions to decrease the likelihood of falling.

Recreationally active refers to individuals who participate in regular physical activity (3 days/week, 30 minutes/day, for the previous 3 months). Balance refers to one's ability to remain stable and upright in new environments. Functional balance refers to balance essential for ADLs. Middle to older adults are adults aged 45 years old and older.

Dynamic warm-up interventions (DWI) are multi-planar movements designed to prepare the body for future activities. Self-paced walking interventions (SPWI) are regular ambulatory gait speeds unique to each individual. Finally, instability will be known as using more than an ankle movement to maintain balance.

Prior research has been conducted on strategies to improve balance. In 2019, Denerel et al. completed a study determining the effects of a DWI, static warm-up intervention (SWI) such as an overhead tricep stretch or butterfly stretch, and no warm-up on dynamic balance. Participants in this study included 33 male and 34 female recreational athletes around the age of 20 years old[8]. In a laboratory

setting and on separate days, participants completed all three interventions and had their dynamic balance tested after each completed intervention. It was concluded that all three interventions had positive effects on the dynamic balance among healthy young adults. Similarly, Chatzopoulous et al. (2014) compared the effects of a SWI, DWI, and no warm-up on balance, agility, reaction time, and movement time in 31 female high school athletes[9]. Chatzopoulous et al. found that a DWI had greater positive effects on balance, agility, and movement time than a SWI[9]. In another similar study, Morrin and Redding (2013) determined the effects of a DWI, SWI, combination of both, and no warm-up on balance, vertical jump, and range of motion (ROM) in female dancers aged 22-32[10]. Morrin and Redding found that a combination of a DWI and SWI elicited the greatest improvements in balance, vertical jump, and ROM[10]. In yet another study, Köse and Atan (2015) compared the effects of a SWI, DWI, and jogging on flexibility, jumping, and balance in college-aged males[11]. They found DWI and SWI elicited greater improvement in balance than jogging. Interventions utilized in Denerel et al. (2019), Chatzopoulous et al. (2014), Morrin and Redding (2013), and Köse and Atan (2015) were short-term interventions aimed at improving the balance among healthy, active individuals[8,9,10,11]. Looking at a longer-term study, Fraser et al. (2017) studied 72 older adults, ≥ 60 years old, for 12 weeks[12]. In the study, the older adults completed a training intervention and balance assessment protocol three times a week. Training interventions included physical movements such as stretching or walking and non-physical training such as cognitive or computer training. Results showed that physical movement alongside cognitive training can be beneficial in improving or maintaining balance. This suggests that these same interventions can decrease FR[12]. When looking at participant characteristics, Denerel et al. (2019) tested on recreational athletes roughly 20 years old[8]; Chatzopoulos et al. (2014) studied females around age 17[9]; Morrin and Redding (2013) studied 22-32-year-old dancers[10]. Similarly, Köse and Atan (2015) studied males around 20 years old from the Faculty of Yasar Dogu Sport Sciences, and another study by Chand, Nuhmani, and John (2013) utilized college-aged female and male participants[11,13].

While the above studies explore different interventions on balance, literature on the effects of DWI and walking interventions (WI) on acute FB and FR have gaps due to a lack of variety in methodology and participants. Denerel et al. (2019) explains the need for future studies focused on DWI and FB without warm-ups prior to the DWI[8]. Chatzopoulos et al. (2014) and Morrin and Redding (2013) demonstrate this use of a warm-up design noted by Denerel et al. by having participants complete an unspecified cardiovascular warm-up followed by dynamic, static, or combination warm-ups or no warm-up, and then post-test[9,10,8].

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Each of these studies took place over the course of three to four days. A gap in the literature is caused by a lack of studies focusing on the DWI's impact on balance without cardiovascular exercises as a warm-up. Denerel et al. (2019), Chatzopoulos et al. (2014), and Morrin and Redding (2013) used the same methodology of comparing the effects of DWI on balance to static stretching, combination stretching, and resting[8,9,10]. No literature was found comparing the acute effects of a DWI to walking on FB. No studies or data were found on the acute impact of specifically DWI and SPWI on the FB of recreationally active middle to older aged adults. It is important that research is conducted to fill these gaps because falls have proven to be common in and highly impactful on middle to older aged adults. Using quick interventions such as 15-minute DWI or SPWI may have the potential to increase FB and decrease FR.

The present study is important because current literature has not looked at the acute effects of a SPWI versus DWI on FB and FR. With an increasing number of middle to older aged adults and fall prevalence in the United States, it is imperative for interventions that can improve FB and decrease FR to be found and studied. Additionally, the population of recreationally active older individuals was selected because recreationally active older individuals may be more apt to incorporate new movement programs into their daily exercise versus inactive individuals. However, because of their age, they are still at increased risk for falls, so it is beneficial for them to continue working on their FB. For this reason, the purpose of this study was to examine the acute impact of DWI and SPWI on the FB and FR of recreationally active and exercise accustomed individuals aged ≥ 45 years old. If an improvement in FB is observed, a recommendation to perform DWI or SPWI each day can be made to decrease the likelihood of falling in the specified population. It was hypothesized that a DWI will show greater acute improvements on FB and FR in middle to older aged adults than SPWI. This study is unique from current research as it compares the effectiveness of a DWI and SPWI without prior cardiovascular exercise on FB in middle to older aged adults.

Methods

Participants

Forty-three participants in a community exercise program offered by a Midwest United States institution were contacted. Inclusion criteria consisted of being recreationally active, ambulatory, exercise accustomed, and ≥45 years of age. No exclusion criteria was present regarding sex, preexisting conditions, or current and previous medications. Sixteen volunteers contacted researchers and all sixteen met the inclusion criteria. Participants were made aware of their right to withdraw from participation at any point throughout the study; their right to remain anonymous during the presentation of collected data; their right to confidentiality; and were

informed of the potential benefits and risks of participation. Prior to participation, each participant also signed an informed consent form.

Instrumentation

To collect information on the acute effects of a dynamic warm-up intervention and a self-paced walking intervention on FB and FR, The Brief-BESTest (Brief-Balance Evaluation Systems Test) was used. The Brief-BESTest tool was acquired and adopted from a study done by Padgett et al. (2012) which validated the test among middle aged participants (average 50 years old)[14]. The Brief-BESTest had strong interrater reliability (intraclass correlation coefficient (ICC) of .959-.994). The ICC compares the proximity of two or more testers' results to each other. Additionally, The Brief-BESTest was valid; it was 100% accurate in identifying participants who reported zero falls or at least one fall in the last three months. Cumulative Brief-BESTest values less than 12.5 identified participants at risk for one or more fall, while scores above 12.5 indicated no fall risk[15].

Additionally, The Brief-BESTest was studied by Marques et al. in 2016 to determine its interrater reliability, test-retest reliability, and validity when tested on older populations (average 76 years old)[15]. To determine the test's interrater reliability, ICC was calculated between different testers scoring The Brief-BESTest. Results concluded that The Brief-BESTest had an ICC equal to .93. Likewise, The Brief-BESTest demonstrated excellent test-retest reliability shown by an ICC of .82. Pertaining to fall risk and validity, Marques et al. (2016) concluded that "[The Brief-BESTest] had an acceptable ability to differentiate participants with and without a history of falls"[15]. This differentiation was done through The Brief-BESTest's set test scoring values of 0-3. Zero denotes severe balance dysfunction, while three denotes no balance dysfunction. The acceptable ability to differentiate participants with and without a history of falls through these 0-3 values was calculated by 'Area Under the Curves' (AUC). AUC scores of <0.5 mean no discrimination, and a score of >0.9 mean outstanding discrimination. Marques et al. (2016) found The Brief-BESTest to have an AUC of .76[15].

Procedures

Participation in this research study consisted of sessions that were 45 minutes/day for 3 days (each session 48-72 hours apart). On the first day of participation, eligible and voluntary participants were read a cover letter, given the opportunity to ask questions about the procedures, signed a written informed consent, completed a health questionnaire, and were guided through a familiarization of The Brief-BESTest. The questionnaire was voluntarily completed by each participant. The questionnaire inquired about participant age, sex, fear of falling, falls within the last year, diagnosis of chronic conditions, and any prescribed medications that are known to impact balance. While

completing the familiarization session, participants watched demonstration videos of each of the six protocols (Biomechanical Constraints, Stability Limits, Transitions-Anticipatory Postural Adjustment, Reactive Postural Response, Sensory Orientation, Stability in Gait) in The Brief-BESTest. The corresponding speaking prompts listed on The Brief-BESTest scoring form were simultaneously read to the participant over the video instructions. Participants were given the opportunity to ask questions and practice the six protocols listed above (without shoes or socks per The Brief-BESTest protocol). No scores were recorded. This completed day one of the protocol.

Day two of testing procedures started with participants watching the same demonstration videos with corresponding audio and completing the same six Brief BESTest protocols as they did on day one of the procedures. Scores were taken based on each protocol's specific scoring scale as listed on The Brief BESTest form. Participants were asked to complete no physical activity prior to this Brief BESTest pre-intervention test. Also prior to testing, participants one through eleven were randomly assigned, via an online randomization website, to complete a 15-minute DWI or 15-minute SPWI. Participants twelve through sixteen were assigned to DWI or SPWI through an every other pattern as they randomly enrolled in the study. On day two, those completing the SPWI were read a prompt outlining the SPWI (15 minutes of walking at a regular ambulatory gait speed unique to each individual in lane 4 / 5 of the institution's indoor track). Those completing the DWI were read a prompt outlining the DWI (15 minutes of dynamic warm-ups; 15 exercises, 40 seconds on, 20 seconds of rest; during the 20 seconds of rest, watch a short demonstration video with corresponding descriptive audio of the next dynamic exercise to be completed; see Table 1 for the list of warm-ups). After completing either the DWI or SPWI, participants were asked to once again remove their shoes and socks to complete a post-intervention test using the same six Brief-BESTest protocols that were completed at the beginning of the session. Scores were again taken based on each protocol's specific scoring. This completed day two of the protocol.

Day three of testing procedures was identical to day two of testing procedures, however, the intervention completed (DWI or SPWI) was opposite to the one randomly assigned on day two. This allowed for all participants to complete both interventions. The methodology of having each participant complete both the DWI and SPWI in a random order on different days is 'counterbalancing' and a 'repeated measures design.' The familiarization session on day one and the overall counterbalanced design were both used to limit the 'carry-over effect' ('learning effect') as a threat to internal validity.

Table 1. Dynamic Warm-Up Exercises.

1. Scoops	9. Side shuffles with arm swings
2. Open the gate/close the gate	10. Frankensteins
3. Tiptoe walk with forward arm circles	11. Karaoke
4. Heel walk with backward arm circles	12. Side Lunges
5. High knees	13. Hip Rocks
6. Butt Kicks	14. Cherry Pickers
7. Lunge with twist	15. Tips (one leg RDLs)
8. Knee to chest	

Note. All participants completed the dynamic warm-up intervention in the order listed above. Prompts were given in the form of visual and auditory cues.

Statistical analyses

To analyze the data collected during this study, Statistical Package for the Social Sciences (SPSS) 27.0 was utilized. Frequencies were used to determine participant characteristics and descriptive statistics were used to find the average scores of The Brief BESTest. A two-way repeated measures ANOVA test was utilized to determine pretest/posttest differences, DWI/SPWI group differences, and pretest/posttest and DWI/SPWI group interactions effects.

Results

Sixteen people began research participation by signing an informed consent form. No participants withdrew from the study. (See Table 2 for participant characteristics and Figure 1 for percent distribution of self-reported fear of falling across participants.) Using an alpha of .05, the two-way repeated measures ANOVA indicated time (pretest vs. posttest) was not a significant predictor of balance, $F(1,15) = 0.00$, MSE = 2.20, $p = 1.00$ but type (DWI vs. SPWI) was a significant predictor of balance, $F(1,15) = 9.20$, MSE = 1.53, $p = .008$, meaning that the marginal means of balance between pre- and posttests for dynamic warm-up were significantly higher than those of self-paced walking. In addition, no significant interaction effect was examined, $F(1,15) = 0.09$, MSE = 2.72, $p = .766$. (See Table 3 for means and standard deviations of The Brief BESTest at pre and post tests for dynamic warm-up intervention and self-paced walking intervention.)

Table 2. Participant Characteristics.

Variable	Characteristics
Sex	
Males	62.5% (*n* = 10)
Females	37.5% (*n* = 6)
Age (years)	68.06 ± 4.50
Pre-existing health conditions	Back pain, osteoarthritis, osteoporosis, C5-C7 vertebrae issues, fluid accumulation in knees, type II diabetes, hypertension, high cholesterol, stroke, sleep apnea, diastasis, hip replacement, knee replacement, tendonitis, spinal stenosis, torn rotator cuff, peripheral neuropathy
Medications affecting balance	Eliquis, gabapentin

Table 3. Descriptive Statistics for Scores of The Brief-BESTest.

Warmup	Time	Mean	Standard Deviation
Dynamic Warmup	Pre	20.69	3.20
	Post	20.81	3.93
Self-Paced Walking	Pre	19.88	3.81
	Post	19.75	3.40

Note. n = 16 per cell

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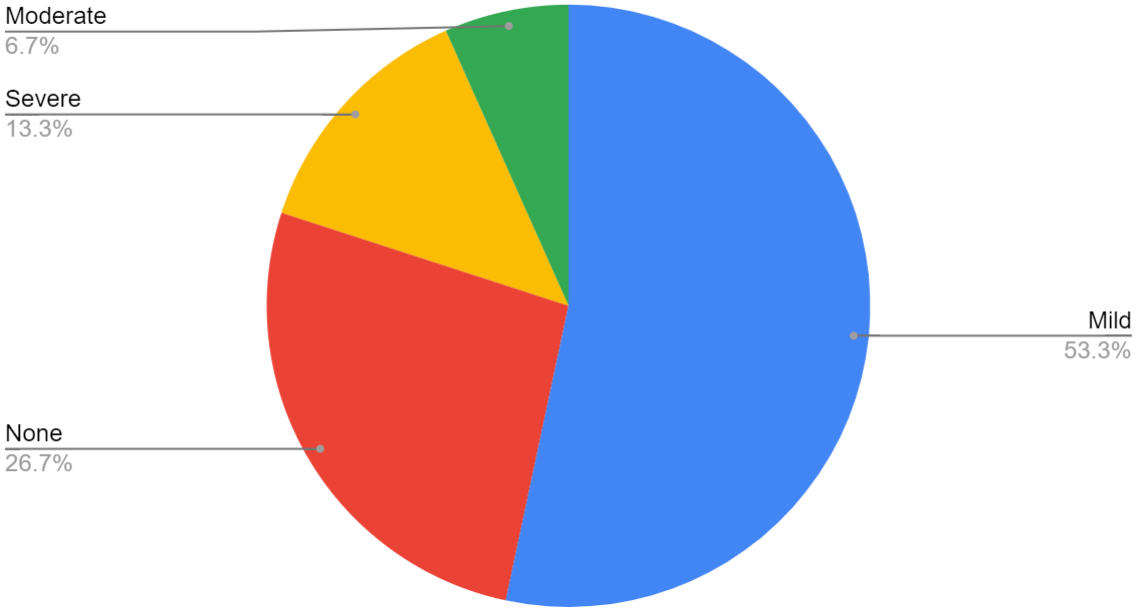
Figure 1. Self-Reported Participant Perceived Fear of Falling



Discussion

Each year, 30% of older adults sustain a fall[4]. These falls commonly cause hip fractures, undifferentiable bone fractures, bruises, functional decline, and death[1,2]. Utilizing this information, it is reasonable that 73.3% of this study's participants possess some fear of falling (see Figure 1). Because of these negative consequences associated with falling and the fear of falling in middle to older aged adults, it is important for research to provide ways for this population to increase FB, and consequently decrease FR. This being said, current literature fails to test the acute effect of DWI on FB and FR of middle to older aged adults. It is for this reason that this study proves to be important. This study hypothesized that a DWI will show greater acute improvements on FB and FR in middle to older aged adults than SPWI.

The descriptive data for The Brief-BESTest scores for both the DWI and SPWI's pretest and posttest were calculated using SPSS version 27.0. All mean scores were found to be nearly identical, suggesting no significant improvements between pre and post intervention FB. The two-way repeated measures ANOVA test results displayed no statistical significance between time and FB, demonstrating no difference in FB from pretest to posttest for both the SPWI and DWI. While FB scores were significantly higher for DWI's pretest and posttest as compared to SPWI pretest and posttest, the finding was insignificant because there were no improvements from pretest to posttest for either intervention type. The study was counterbalanced to avoid this finding, however, most participants still performed

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better overall on DWI days for unclear reasons. One potential reason for this finding considers the participants holding a preconceived idea of the study hypothesis, and therefore unconsciously performing better on DWI test days. Outside of this finding, there was no statistical significance between the type of intervention and FB, thus demonstrating no observed difference between the effect of SPWI on FB and the effect of DWI on FB. It is also important to make note that there was no significant interaction effect found between pretest/posttest and DWI/SPWI suggesting that The Brief-BESTest scores were not dependent upon one another.

The lack of significant improvements between pre/post DWI and SPWI contrasts current literature. Additionally, these findings contrast the study hypothesis that was formulated upon current literature which shows DWI significantly improving the FB of tested populations. Current literature that shows this improvement include: Chatzopoulos et al., 2014, Köse et al., 2015, Denerel et al., 2014, and Morrin and Redding, 2013[9,8,11,10]. Chatzopoulos et al. found that DWI had a significant impact on FB, even more so than SWI[9]. Similarly, Köse et al. concluded that DWI significantly improved FB scores. Denerel et al. found that DWI, SWI, and jogging all positively and equally impacted FB scores[8]. Additionally, Morrin and Redding found that a combination of a DWI and SWI elicited the greatest improvements in balance[10]. While the study findings deviate from current literature, results may simply indicate that neither DWI nor SPWI have a significant acute effect on FB of active, exercise-accustomed middle to older aged adults. This said, both or one intervention may still have a significant long-term effect on FB of inactive middle to older aged adults.

This study contained many strengths despite DWI and SPWI showing no acute effects on the FB of middle to older aged adults. One strength of this study was the limited use of exclusion criteria. By broadening the range of participants eligible for participation, the acute effect of DWI and SPWI on FB was tested on different health conditions included but not limited to stroke, diabetes, hypertension, hip and knee replacements, tendonitis, spinal stenosis, and peripheral neuropathy. There were two participants who were taking medications (Eliquis and gabapentin) which have a known side effect of dizziness or decreased balance. This can be considered a strength because it provides a realistic, real-world example of how FB can be affected by a variety of common conditions and medications. Additionally, this study included ten males and six females. This can also be considered a study strength because it allows the results to be extrapolated to both sexes. The study also included a familiarization session on day one and a counterbalanced method used throughout to minimize the 'carry-over effect' ('learning effect') as a threat to internal validity. Another strength of this study was the standardized procedure. Multiple scripts and directional videos were utilized to eliminate interrater variability between the testers. By doing this, each participant received standard directions and cues, aside from any additional clarification

that was needed. Finally, another strength of this study was the middle to older aged adult population. Current literature focuses on DWI and FB, but on 18–30-year-olds[8], high school students[9],and traditional college aged students (Köse et al., 2015), not middle to older aged adults. As emphasized, because middle to older aged adults fall more frequently than young adults, have an increased fear of falling, and there currently being 49.2 million Americans ≥ 65 years old, it is important that interventions to improve FB and decrease FR are explored[16].

This study contained a few limitations. First, after the conduction of the study and a lack of statistically significant improvements between the pretests and posttests of both DWI and SPWI, it was determined that The Brief-BESTest may not be sensitive enough to identify acute effects of DWI on FB of healthy, middle to older aged adults. Additionally, including healthy, exercise-accustomed middle to older aged adults in this study may be at fault for the lack of improvements between pretests and posttests. Conducting this study on less healthy, less exercise-accustomed individuals may have produced results with acute FB effects. This population may be affected more because of potential decreased balance overall or susceptibility to FB changes. Finally, the small sample size may serve as a limitation. In this study, 16 participants completed testing. Relative to current literature, this study had fewer participants than some. For example, Denerel et al. in 2014 had 67 participants[8]. However, the current study also had more participants than other studies. For example, Morrin and Redding in 2013 had 10 participants[10]**.** A larger sample size may have yielded more accurate results as well as accounted for any variability in data like medications or chronic conditions.

The findings from this study contribute to current literature. One potential contribution is the finding that The Brief-BESTest may not be sensitive enough to find changes in the FB of healthy, exercise-accustomed middle to older aged adults in a short period of time. This is because despite the known reliability and validity of The Brief-BESTest[15], it was not sensitive enough in this study to detect significant changes in FB performances 15 minutes apart. This is an important contribution because if a similar study is repeated in the future, The Brief-BESTest may not yield the most significant results. Another important contribution to current literature is that 73.3% of participants noted some fear of falling. This highlights the prevalence of fear of falling in middle to older aged populations as well as the need for FR prevention.

Ideas for future research in this field are as follows: research may consider focusing on how DWI impacts a participant's perceived FB. During the current study, one participant stated that they 'felt more confident in their ability to prevent themselves from falling post-DWI.' While this study produced no significant data that shows positive acute effects of DWI on FB, future studies may show that one's perceived FB impacts middle to older aged adult confidence, and therefore, FB or FR. Additionally, future research should assess the

acute effect of a DWI on middle to older aged adults who do not meet physical activity guidelines (150 minutes/week). Because the current study took place on recreationally active, ambulatory, exercise-accustomed individuals, participant FB pretest and posttest scores may be significantly higher than people who do not meet this criteria. Because of this, research that is conducted on middle to older aged adults who do not engage in regular physical activity may show more significant FB improvements. Lastly, future research considering the acute effects of DWI and SPWI on FB of healthy, active older adults should be performed with more sensitive instrumentation. While The Brief-BESTest is reliable and valid, as highlighted in Marques et al. in 2016, it may not be sensitive enough to detect significant acute changes in FB of healthy, active individuals[15]. Instrumentation such as the Biodex Balance System may be more sensitive for detecting significant acute changes in FB for future research. According to Parraca et al. in 2011, the Biodex Balance System was determined to be reliable and useful for measuring FR.

Conclusion

The findings of this study conclude that neither DWI or SPWI induce a significant acute effect on FB and therefore, FR. Implications of this study include interventions to improve FB may prove to be more successful when implemented long-term, The Brief-BESTest may not be sensitive enough to detect acute changes in FB, and that studies focusing on less healthy, inactive individuals may show changes in FB post intervention. Future research may consider these findings and implications by studying middle to older aged, inactive populations with higher FR or utilizing an instrument more sensitive to acute changes in FB. Through these adjustments, research may show significant improvements in the FB and FR of middle to older aged adults using DWI or SPWI. Additionally, if inactive individuals are studied, data can be extrapolated to these populations and prevent the negative impacts of falls in this segment of the population.

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