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# The Effect of Long-Haul COVID-19 on Balance Confidence in Older Adults

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Accepted in Partial Completion
of the Requirements for the Degree
*Master of Science*

ADVISORY COMMITTEE

Dr. Harsh Buddhadev, Chair

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## Abstract

The effects of long COVID 19 on balance and fall risk in older adults are unknown. This study assessed balance confidence and fear of falling in older adults (≥ 60 years) with long COVID (long-haulers, $n = 30$) compared to older adults who experienced COVID but not long COVID (non-long-haulers, $n = 60$) and older controls who never had COVID ($n = 52$). Participants completed the Activities-Specific Balance Confidence (ABC) Scale and the Falls Efficacy Scale International (FES-I). Mean total ABC Scale scores indicated lesser balance confidence in older long-haulers compared to non-long-haulers ($p < .001$) and controls ($p = .011$); mean total FES-I scores indicated greater fear of falling in older long-haulers compared to non-long-haulers ($p < .001$ ) and controls ($p = .027$). Compared to established cut-off guidelines, these results indicate that older long-haulers may be at greater risk of falling compared to older non-long-haulers and controls.

*Keywords*: long COVID, post acute COVID syndrome, long-haul COVID, balance, balance confidence, fall risk, older adults

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**The Effect of Long-Haul COVID-19 on Balance Confidence in Older Adults**

COVID-19 is a highly infectious viral disease caused by SARS-CoV-2 (Chen et al., 2020; Shahid et al., 2020). Common symptoms of this condition include shortness of breath, fever, fatigue, loss of smell or taste, and dry cough. Other less common symptoms include muscle pain or weakness and delirium (Arentz et al., 2020; Wang et al., 2020). In the United States, older adults are disproportionately affected by this disease. For example, older adults aged 65 years and older make up 17% of the U.S. population, but 31% of confirmed COVID-19 infections, 45% of hospitalizations for COVID-19, 53% of intensive care unit stays for COVID-19, and 80% of COVID-19 deaths (CDC, 2021). Furthermore, the incubation period for this condition is longer in older adults, with more rapid disease progression and shorter mean times between initial infection and fatality (Cesari & Montero-Odesso, 2020; de Souza et al., 2020; Gómez-Belda et al., 2020; Kong et al., 2020). In addition to the common symptoms mentioned above, older adults infected with COVID-19 also have a high prevalence of falls. For instance, 25% of older adults with COVID-19 were initially admitted for a fall or presented with a fall at symptom onset (Vrillon et al., 2020). Furthermore, 36% of older adults with atypical COVID-19 symptoms such as confusion, delirium, and muscle weakness reported falls (Gan et al., 2020). However, it is not yet known whether this increased fall risk persists after recovery from acute COVID-19 infection in older adults, or if this fall risk is exacerbated in COVID-19 long-haulers.

According to the National Institute of Health and Care Excellence (NICE) (2020), COVID-19 long-haulers are individuals who continue to show symptoms for four or more weeks after the onset of infection. A non-long-hauler is a COVID-19 survivor in whom the symptoms lasted less than four weeks. For patients who become long-haulers, clinical features associated with fall risk, such as muscular weakness, fatigue, and potential cognitive decline, tend to be more prevalent. For example, 52.3% of COVID-19 long-haulers experienced fatigue more than six weeks after recovery (Townsend et al., 2020), 28.3% of long-haulers reported physical decline or fatigue 3 months after discharge from a hospital for COVID-19 treatment (Xiong et al., 2020), and 63% of long-haulers reported fatigue or muscle weakness approximately six months after symptom onset (Huang et al., 2021). Regarding cognitive decline, approximately 33% of survivors of severe COVID-19 demonstrated cognitive impairment (manifesting as inattention, disorientation, or poorly organized movements in response to command) at hospital discharge (Helms et al., 2020). In addition, there is emerging evidence for more potential cognitive decline in COVID-19 long-haulers, indicated by difficulty concentrating and memory function when compared to non-long-haulers (Sudre et al., 2021). Yong (2021) also speculated that potential cognitive dysfunction could occur following damage to the brainstem during COVID-19 infection. With these sequelae in mind, discerning between COVID-19 long-haulers and non-long-haulers is especially important in older adults because the motor and cognitive systems affected by COVID-19—both of which are involved in balance maintenance—also typically decline with age. For example, aging leads to deterioration in the motor system, including a decreased ability to rapidly produce adequate muscular power in response to balance perturbations (Evans & Lexell, 1995). Also of note is an observed decrease in muscular endurance, meaning that older adults fatigue more quickly, potentially increasing the risk of a fall (Carmeli et al., 2002). In addition, cognition tends to be slower in older adults, with deficits to attention, memory, and multi-tasking ability (Allen et al., 2014; Bowles & Poon, 1982; Madden, 2007; Morris & McManus, 1991). Because balance is needed during basic and instrumental activities of daily living (ADLs), and balance is an independent risk factor for falls, it is critical to understand the cumulative effects of aging and long-haul COVID-19 on fall risk in older adults. This becomes especially significant considering that falls are the most common cause of injury and emergency admission in older adults, as well as the leading cause of injury-related death, loss of functional ability, loss of independence, and decrease in quality of life for older adults (Kenny et al., 2017). Overall, aging increases fall risk, but it remains unknown if this risk is exacerbated in long-haulers. Because long-haul COVID-19 often includes fatigue, muscle weakness, and potential cognitive decline, balance during basic and instrumental activities of daily living may be impacted in long-haulers, potentially increasing their fall risk. Other factors associated with increased fall risk have been noted in long-haulers as well, including depression and general pain or discomfort (Xiong et al., 2020).

Considering the potential compounding effects of aging and long-haul COVID-19 on fall risk, it is valuable to assess balance during activities of daily living for older long-haulers. Two established and validated questionnaires, the ABC Scale (Powell & Myers, 1995) and the FES-I (Yardley et al., 2005), are commonly used to determine balance efficacy and concern about falling during ADLs in older adults. Although these questionnaires do not directly measure balance ability, they have been validated against clinical tests used to measure balance ability, such as the Berg Balance Scale. For instance, the ABC Scale demonstrates moderate to strong correlation with the Berg Balance Scale in noninstitutionalized women 70 years and older ($r = 0.57$, $p < 0.001$) (Talley et al., 2008) and community-dwelling older adults ($r = 0.752$, $p < 0.01$) (Hatch et al., 2003). A moderate correlation has also been demonstrated between the FES-I and the Berg Balance Scale in community-dwelling older adults ($r = -0.62$, $p < 0.0001$) (Dhaval et al., 2020). Furthermore, an advantage of these questionnaires is that they require no physical proximity, making them a safe and feasible way to gather data in a contagious COVID-19 pandemic. They also cover a broad and applicable range of basic and instrumental ADLs, which are key areas for fall risk assessment. Using the total score from these questionnaires, fall risk in older adults can be evaluated by comparing it with known cut-off points or reference standards. For example, Lajoie & Gallagher (2004) found that score of below 67% on the ABC Scale indicates substantial risk of falling in older adults, with a sensitivity of 84.4% and specificity of 87.5%. Likewise, Delbaere et al. (2010) determined the following criterion values for the FES-I: a score of 16 to 19 indicates a low concern for falling, 20 to 27 indicates a moderate concern for falling, and 28 to 64 indicates a high concern for falling in older adults.

In summary, an examination of fall risk in older COVID-19 long-haulers is invaluable to their care and treatment; it could allow us to be proactive about the needs of older long-haulers in terms of identifying individuals at a greater fall risk, as well as advocating for factors related to their care, including education, resources, and funding. Therefore, the purpose of this study is to evaluate the fall risk via assessment of balance confidence and fall efficacy during ADLs using validated questionnaires in older COVID-19 long-haulers, COVID-19 non-long-haulers, and healthy controls. We hypothesize that balance confidence and concern about balance are more adversely affected in older COVID-19 long-haulers compared to older COVID-19 non-long-haulers and older controls.

## Methods

### *Participants*

For the current study, the participants were older adults of all genders between the ages of 60 to 90 years in the United States. Within this older population, the three groups of participants were older COVID-19 long-haulers, older COVID-19 non-long-haulers, and older controls. A COVID-19 long-hauler was operationally defined as an individual who self-reported experiencing COVID-19 symptoms four or more weeks after initial symptom onset (NICE, 2020). A COVID-19 non-long-hauler was defined as an individual infected with COVID-19 who did not self-report symptoms for four or more weeks after symptom onset (NICE, 2020). The control group consisted of individuals who self-reported never contracting COVID-19. Exclusion criteria were unknown status of past self-reported COVID-19 infection, presence of dementia or other cognitive disorders that would affect the participant's understanding of the questions within the ABC Scale and the FES-I, and insufficient knowledge of the English language to complete the task (Delbaere et al., 2010; Delbaere et al., 2013). Since there is no prior data available for the ABC Scale and FES-I in the population groups of interest in our study, we conducted a generic power analysis for a one-way ANOVA with three groups using GPower 3.1 software to determine the sample size. To obtain a statistical power of 0.8 at an alpha level of 0.05 for a moderate effect size group difference (Cohen's $f$ = 0.25), a minimum sample size of 159 participants (i.e. 53 participants per group) was estimated. The participants for this study were recruited from local community centers, nursing homes, senior centers, online forums, and social media platforms (FaceBook, Twitter). This study was approved by the Human Subjects Review Board at Western Washington University prior to data collection. All participants gave electronic or verbal informed consent prior to participating in the study.

***Procedure***

All participants completed a survey which included questions on demographic characteristics, COVID-19 infection history, COVID-19 symptom onset and duration, the ABC Scale, and the FES-I administered via online survey software (Qualtrics Research Suite, Qualtrics, Sydney), which has been used in previous literature (Boyce et al., 2017; Mohanathas, 2021). Below is information about the ABC and FES-I and their psychometric properties:

**Activities-Specific Balance Confidence Scale.** The ABC Scale is a self-report questionnaire that assesses a subject's activity-specific balance confidence during 16 common basic and instrumental activities of daily living (Powell & Myers, 1995). Participants score each item based on their confidence that they can perform the activity without losing their balance or becoming unsteady, from 0% (indicating no confidence) to 100% (indicating complete confidence). The aggregate score of the ABC scale is determined by taking the average percent confidence given (sum of scores divided by number of items), with lower aggregate scores indicating lower balance confidence. According to a study of community-dwelling older adults, a cut-off score of 67% or below identifies people at risk of falling (Lajoie & Gallagher, 2004). The ABC scale has also been demonstrated to have strong test-retest reliability ($r = 0.92$, $p < 0.001$) (Powell & Meyers, 1995), and strong internal consistency (Cronbach's alpha = 0.96) amongst community-dwelling older adults (Huang & Wang, 2009).

**Falls Efficacy Scale—International.** The FES-I was designed similarly to measure concern about falling during 16 basic and instrumental activities of daily living in older adults, including items relevant to physical activity during social interaction. Participants rate each activity on a scale of one to four based on how concerned they are about falling if they perform that activity; a score of 1 indicates "not at all concerned," 2 indicates "somewhat concerned," 3 indicates "fairly concerned," and 4 indicates "very concerned" (Yardley et al., 2005). The FES-I is scored by summing the scores for each item, yielding a range of 16-64 (Dewan & MacDermid, 2014), with a higher score indicating greater concern about falling. Cut-off scores for the FES-I for community dwelling older adults, established by comparing FES-I scores to balance sway assessment and fall history, is as follows: a score of 16-19 indicates low concern of falling, a score of 20-27 indicates a moderate concern of falling, and a score of 28-64 indicates a high concern of falling (Delbaere et al., 2010).The FES-I has been shown to have strong test-retest reliability (ICC = 0.96) (Dewan & MacDermid, 2014) and strong internal consistency (Cronbach's alpha = 0.96) amongst community-dwelling older adults (Dewan & MacDermid, 2014).

### *Data Analysis*

For the current study, only data from participants meeting the inclusion criteria were analyzed. Data were disregarded for participants who left one or both scales partially or fully incomplete. Data from participants living outside of the United States was not included. Participants who indicated they "did not know" if they had ever contracted COVID-19 were not included in the data analysis, as this prevented them from being classified as a long-hauler, non-long-hauler, or control participant.

### *Statistical Analysis*

In the current study, the independent variable was group (of which there were three—older COVID-19 long-haulers, older COVID-19 non-long-haulers, and older controls) and the two dependent variables were total ABC scale score and total FES-I score. Two Kruskal-Wallis tests were performed to determine the effect of the group (older COVID-19 long-haulers, older COVID-19 non-long-haulers, and older controls) on the cumulative ABC scale and FES-I scores. In the event of significant differences between the groups, a Kruskal-Wallis post-hoc test was used for post-hoc comparisons. The alpha level was set a priori to be less than 0.05. The small, medium, and large effect sizes were Cohen's f of 0.10, 0.25, and 0.40, respectively (Cohen, 1988). All statistical analyses were performed using SPSS (Version 23).

**Results**

Data for this study were collected from October 2021 to January 2023. Demographic characteristics of participants are presented in Table 1. The number of self-reported presence of comorbidities such as diabetes, vertigo, blood pressure issues (e.g. orthostatic hypotension), dementia, Parkinson's disease, Alzheimer's disease, a history of stroke, a history of lung disease, a history of heart disease, or any other conditions that affect balance are also noted in Table 1.

**Table 1**

*Demographic Characteristics of Subject Participants*

| Variables | Control | Non-long-haulers | Long-haulers |
|---|---|---|---|
| *n* | 52 | 60 | 30 |
| Gender | 15 M, 37 F | 22 M, 38 F | 4 M, 26 F |
| Age (years) | 76.31 ± 7.97 | 70.68 ± 8.22 | 67.80 ± 7.77 |
| Participants with comorbidities | $n = 30$ | $n = 37$ | $n = 17$ |
| Hospitalizations for COVID-19 | | $n = 0$ | $n = 5$ |
| Physician confirmation of Long COVID diagnosis | | | $n = 22$ |

*Note.* Age is reported as means ± standard deviations. Gender is reported as M (male) and F (female).

The mean and standard deviations scores for each question of the ABC Scale and the FES-I for all three groups are reported in Tables 2 and 3, respectively.

**Table 2**

*Mean Scores on Each Item of the ABC Scale for Controls, Non-Long-Haulers, and Long-Haulers*

| ABC Scale Prompt | Control (%) | Non-Long-Haulers (%) | Long-Haulers (%) |
|---|---|---|---|
| Walking around the house | 90.0 ± 12.8 | 92.7 ± 14.6 | 72.7 ± 25.5 |
| Walking up or down stairs | 75.6 ± 22.5 | 84.8 ± 20.9 | 56.3 ± 31.1 |
| Bending over to pick up an object | 81.5 ± 19.8 | 88.5 ± 17.7 | 65.0 ± 25.4 |
| Reaching at eye level | 90.0 ± 15.0 | 94.7 ± 15.1 | 77.3 ± 28.9 |
| Reaching above head | 77.1 ± 25.2 | 87.0 ± 19.5 | 59.0 ± 27.3 |
| Standing on chair and reaching | 60.8 ± 31.0 | 76.0 ± 29.1 | 42.7 ± 30.8 |
| Sweeping floor | 88.3 ± 17.5 | 92.8 ± 16.7 | 77.0 ± 25.5 |
| Walking to a car | 87.1 ± 18.9 | 93.2 ± 15.1 | 72.0 ± 27.1 |
| Getting in or out of a car | 86.5 ± 17.8 | 92.7 ± 15.7 | 73.0 ± 25.9 |
| Walking across a parking lot | 85.8 ± 19.4 | 91.5 ± 16.7 | 73.7 ± 27.2 |
| Walking up or down a ramp | 81.9 ± 23.8 | 90.2 ± 16.5 | 67.7 ± 27.3 |
| Walking in a crowded mall | 83.1 ± 19.8 | 90.5 ± 18.3 | 67.3 ± 29.7 |
| Being bumped into while walking | 72.5 ± 25.0 | 84.7 ± 22.2 | 60.3 ± 30.2 |
| Using an escalator holding the railing | 75.6 ± 27.0 | 84.7 ± 20.8 | 57.3 ± 28.8 |
| Using an escalator without holding the railing | 57.3 ± 33.3 | 75.8 ± 26.3 | 43.7 ± 29.1 |
| Walking on icy sidewalks | 45.6 ± 30.0 | 55.7 ± 31.0 | 34.3 ± 28.7 |

*Note.* Data are presented as means ± standard deviations. Individual ABC Scale questions are scored from 0% to 100%, with lower scores indicating lesser balance confidence.

**Table 3**

*Mean Scores on Each Item of the FES-I for Older Controls, Non-Long-Haulers, and Long-Haulers*

| FES-I Prompt | Control | Non-Long-Haulers | Long-Haulers |
|---|---|---|---|
| Cleaning the house | 1.4 ± 0.7 | 1.2 ± 0.6 | 1.7 ± 0.8 |
| Getting dressed or undressed | 1.5 ± 0.6 | 1.3 ± 0.6 | 1.6 ± 0.7 |
| Preparing a meal | 1.3 ± 0.6 | 1.1 ± 0.5 | 1.5 ± 0.8 |
| Taking a bath or shower | 1.7 ± 0.8 | 1.5 ± 0.7 | 2.3 ± 1.0 |
| Going to the shop | 1.4 ± 0.7 | 1.2 ± 0.6 | 1.8 ± 1.0 |
| Getting in or out of a chair | 1.3 ± 0.6 | 1.2 ± 0.5 | 1.7 ± 0.9 |
| Walking up or down stairs | 1.8 ± 0.8 | 1.7 ± 0.8 | 2.5 ± 1.0 |
| Walking in the neighborhood | 1.5 ± 0.6 | 1.3 ± 0.7 | 2.2 ± 1.0 |
| Reaching above the head or to the ground | 1.8 ± 0.8 | 1.5 ± 0.7 | 2.0 ± 0.9 |
| Answering the phone in time | 1.5 ± 0.7 | 1.2 ± 0.6 | 1.6 ± 0.9 |
| Walking on a slippery surface | 2.9 ± 0.8 | 2.6 ± 1.0 | 3.3 ± 0.9 |
| Visiting a friend or relative | 1.3 ± 0.7 | 1.2 ± 0.5 | 1.6 ± 1.0 |
| Walking among crowds | 1.8 ± 0.8 | 1.4 ± 0.7 | 2.0 ± 1.0 |
| Walking on an uneven surface | 2.3 ± 0.9 | 2.0 ± 0.9 | 2.8 ± 1.1 |
| Walking up or down a slope | 2.1 ± 1.0 | 1.7 ± 0.8 | 2.5 ± 1.0 |
| Attending a social event | 1.5 ± 0.7 | 1.3 ± 0.6 | 1.7 ± 1.0 |

*Note.* Data are presented as means ± standard deviation. Individual FES-I questions are scored from 1 to 4, with higher scores indicating greater concern about falling.

Total ABC Scale and total FES-I scores were assessed for normality using Shapiro-Wilks tests; the data were found to be not normally distributed ($p < .05$) for all groups. Levene's tests revealed that the three groups do not display homogeneity of variance for both the total ABC Scale scores ($F_{2,139} = 4.87$, $p = .009$) and the total FES-I scores ($F_{2,139} = 4.34$, $p = .015$). Since the data violated the homogeneity of variance and normality assumptions of a typical one-way ANOVA, a Kruskal-Wallis test was used to examine if significant differences existed amongst the three groups for both total ABC Scale scores and total FES-I scores (Walker, 2010). Effect size was also calculated as Cohen's *f*. A Kruskal-Wallis test revealed a statistically significant difference among the total ABC Scale scores of controls, non-long-haulers, and long-haulers ($H_2 = 25.68$, $p < .001$) with a large effect size (Cohen's $f = 0.46$). There was also a statistically significant difference among the total FES-I scores of controls, non-long-haulers, and long-haulers ($H_2 = 19.45$, $p < .001$) with a medium effect size (Cohen's $f = 0.37$). The mean total ABC Scale and mean total FES-I scores for each group are reported in Table 4.

**Table 4**

*Mean Scores on the ABC Scale and FES-I for Older Controls, Non-Long-Haulers, and Long-Haulers*

| Variable | Control | Non-Long-Haulers | Long-Haulers |
|---|---|---|---|
| ABC Scale Score (%) | 77.4 ± 18.7 | 86.0 ± 17.0 | 62.5 ± 24.5 |
| FES-I Score | 27.0 ± 9.2 | 23.4 ± 8.6 | 32.8 ± 12.0 |

*Note.* Data are presented as means ± standard deviations. The ABC Scale is scored from 0% to 100%, with lower scores indicating lesser balance confidence. The FES-I is scored from 4 to 64, with higher scores indicating greater concern about falling.

Pairwise Kruskal-Wallis post-hoc testing revealed that all groups' total ABC Scale scores were significantly different from each other ($p < .05$). Lower total ABC Scale scores indicate less balance confidence; as reported in Table 4, the mean total ABC Scale scores were significantly lower for long-haulers compared to healthy controls ($p = .011$) and compared to non-long-haulers ($p < .001$). Furthermore, the mean total ABC Scale scores were greater for non-long-haulers compared to healthy controls ($p = .005$).

Similarly, additional pairwise Kruskal-Wallis post-hoc testing revealed that all groups' total FES-I scores were significantly different from each other ($p < .05$). Higher FES-I scores indicate greater concern about falling; as demonstrated in Table 4, the mean total FES-I scores were significantly higher for long-haulers compared to healthy controls ($p = .027$) and compared to non-long-haulers ($p < .001$). Furthermore, mean total FES-I scores were greater for healthy controls than for non-long-haulers ($p = .015$).

**Discussion**

We had hypothesized that balance confidence and concern about falling are more adversely affected in older COVID-19 long-haulers compared to older COVID-19 non-long-haulers and older controls. Analysis of the data collected supports this hypothesis with medium to large effect sizes for both the ABC Scale and FES-I; older long-haulers had significantly lower balance confidence and greater concern about falling than non-long-haulers and healthy controls. Previous research on the ABC Scale established that a total score of below 67% indicates substantial risk of falling in older adults (Lajoie & Gallagher, 2004). The mean total ABC Scale data indicates that long-haulers ($M = 62.5 \pm 24.5\%$) fall in this category of increased fall risk, while non-long-haulers ($M = 86.0 \pm 17.0\%$) and controls ($M = 77.4 \pm 18.7\%$) do not. Similarly, Delbaere et al. (2010) determined the following cut-off values for the FES-I: a total score of 16 to 19 indicates a low concern for falling, 20 to 27 indicates a moderate concern for falling, and 28 to 64 indicates a high concern for falling in older adults. The mean total FES-I scores indicate that long-haulers ($M$ = 32.8 ± 12.0) are at high risk for falls and non-long-haulers ($M$ = 23.4 ± 8.6) and controls ($M$ = 27.0 ± 9.2) are at a moderate risk for falls. This study's data with respect to these cut-off scores for fall risk indicate that older long-haulers who have lower balance confidence and increased concern about falling may be at higher risk for a fall.

Older long-haulers may be at a higher fall risk due to the combined effects of aging and long COVID on balance ability. For example, aging affects balance across many systems, such as motor system deterioration, decreased ability to produce adequate muscle power, decreased muscle endurance, slower cognition, and deficits in attention, memory, and multi-tasking (Allen et al., 2014; Bowles & Poon, 1982; Carmeli et al., 2002; Evans & Lexell, 1995; Madden, 2007; Morris & McManus, 1991). The effects of long-haul COVID, including fatigue, muscle weakness, and cognitive impairment (Helms et al., 2020; Huang et al., 2021; Sudre et al., 2021; Xiong et al., 2020) may compound the effects of aging on the motor and cognitive systems of older adults, leading to the decreased balance confidence and increased fall risk seen in this study. It is also possible that motor and cognitive ability could have been impacted by initial COVID-19 infection itself, by hospitalization, or by treatment for initial infection.

***Comparisons to Other Literature***

To the authors' knowledge, this is the first study to provide balance confidence and concern about fall risk data in older long-haulers. Since no previous research has examined balance in older COVID long-haulers, we could not compare our results to other studies. However, the total mean ABC Scale and FES-I score data for the healthy control group can be contrasted with healthy older controls in other studies. This study's control group's mean total

ABC Scale score (*M* ± SD = 77.4 ± 18.7) indicated lesser balance confidence compared to a control group of 21 older adults without mild cognitive impairment (*M* ± SD = 81.7 ± 21.7) (Rolenz & Reneker, 2016), a control group of 12 older non-golfers (*M* ± SD = 92.6 ± 7.3) (Gao et al., 2011), and a control group of 30 older adults without Parkinson's disease (*M* ± SE = 93.2 ± 1.3%) (Adkin et al., 2003). Similarly, this study's control group demonstrated greater fear of falling based on the mean total FES-I scores (*M* ± SD = 27.0 ± 9.2) compared to a control group of 101 older adults without diabetes (*M* ± SD = 21.1 ± 7.3) (Tander, 2016), a control group of 25 older adults without chronic obstructive pulmonary disease (*M* ± SD = 20.2 ± 5.52) Oliveira et al., 2015), and a control group of 60 older adults without rheumatoid arthritis (*M* ± SD = 18.81 ± 4.58) (Akyol et al., 2018). Had the total mean ABC Scale and FES-I scores of this study's control group more closely matched those of previous literature, the differences between the control group and the long-hauler group may have been even more pronounced. It is important to note that of the 52 participants in this study's control group, 30 reported having a non-COVID condition that has the potential to affect balance. These conditions included diabetes, vertigo, blood pressure issues (e.g. orthostatic hypotension), dementia, Parkinson's disease, Alzheimer's disease, a history of stroke, a history of lung disease, and a history of heart disease.

### *Limitations*

There were two main limitations in this study: potential distinctions based on symptom severity and identifying the specific source of increased risk. Firstly, long COVID's classification solely by duration of symptoms may impact participant recruitment. Examining the duration of symptoms to distinguish between long-haulers and non-long-haulers disregards potential differences in symptom severity; for instance, subjects who experienced severe debilitation in daily life and subjects whose only symptom was loss of smell were categorized together. If severity of symptoms were accounted for as well as symptom duration, differences in balance confidence and fall risk may have been even more pronounced. Further distinctions within groups based on both symptom duration and severity may be necessary in future research in order to gain a more nuanced insight into long COVID. Secondly, though the data indicate a greater fall risk among older long-haulers, the specific source of this risk is not clear; it could be long-haul COVID, secondary sequelae of initial COVID infection, the effects of hospitalization or treatment, or other causes. Identifying what specifically caused this increased fall risk in long-haulers is beyond the scope of this thesis; regardless of cause, the group is at greater risk.

***Directions of Future Research***

Future studies could distinguish between different COVID infection experiences (symptomatic or not, severity level, whether hospitalization was required) and different long-haul experiences (symptoms, severity of symptoms, impact on daily life) in order to further identify which long-haulers are at greatest risk. Further research could also benefit from a larger sample size of long-haulers, the use of field and lab tests to assess balance, and longitudinal assessment of how fall risk changes in older long-haulers over time. This would help gain a more robust understanding of the balance limitations of this demographic. Additionally, though we did not run statistical analysis on individual ABC Scale or FES-I questions, differences in mean responses for each group (see Tables 3 and 4) give insight into directions for future research on which basic or instrumental activity of daily living may be more affected. For instance, long-haulers had lesser balance confidence and greater fear of falling walking up and down stairs, taking a bath or shower, and reaching for items than non-long-haulers and healthy controls. These differences warrant further examination into balance confidence in specific basic and instrumental activities of daily living.

***Conclusions***

Overall, older long-haulers have decreased balance confidence and increased fear of falling compared to non-long-haulers and health controls, which may indicate a greater fall risk. The results of this study indicate that older long-haulers may have a heightened need for resources and healthcare services, including balance training, direct caregiving, and living environment adaptations. Such outreach could be vital in fall prevention for older adults with long-haul COVID-19.

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# Appendix A: Review of Pertinent Literature

This review will explore possible connections between long-haul COVID-19, balance confidence, and fall risk in older adults. COVID-19's morbidity, mortality, disease progression, and symptoms will be presented, with a focus on the manifestation of COVID-19 in older populations. The phenomenon of long-haul COVID-19 will also be discussed. A thorough understanding of long-haul COVID-19, including its morbidity and symptoms, is critical in determining its potential effects on balance-related systems. For context, systems of the body integral to balance maintenance will be broadly reviewed, followed by a general discussion of how these systems can be adversely affected by age. Finally, methods of balance, balance confidence, and fall risk assessment in older adults will be appraised, with a detailed examination of the development, rationale, criterion values, and use of two self-report questionnaires. In this review, the author hopes to identify potential connections amongst long-haul COVID-19, age-related deterioration of systems required in balance, and balance confidence and fall risk in older adults.

## COVID-19

### *What is COVID-19?*

COVID-19 is the disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a highly infectious virus spread through respiratory droplets and aerosol transmission (Chen et al. 2020; Shahid et al., 2020). With a median incubation period of 5.1-8.3 days, most symptomatic COVID-19 patients experience symptoms for two weeks (Kong et al., 2020; Shahid et al., 2020). Severe cases of COVID-19 often require hospitalization, mechanical ventilation, and other forms of critical illness support. Common symptoms of this condition include shortness of breath, fever, fatigue, loss of smell or taste, and a dry cough. Less common symptoms can include headache, a nausea, cough with sputum production, myalgia, chills, nausea, vomiting, and diarrhea (Arentz et al., 2020, Wang et al., 2020). Rare symptoms can include sore throat and delirium (Wang et al., 2020). COVID-19 often leads to systemic inflammation, sometimes referred to as a “cytokine storm” (Chen et al., 2020), as well as organ damage due to acute respiratory distress, acute kidney injury, cardiac injury, and liver dysfunction (Arentz et al., 2020).

### *Mortality and Morbidity Statistics for General Population and Older Adults*

Over 30 million residents of the United States have contracted COVID-19, and over 550,000 people have died from COVID-19 in the United States (WHO, 2021). Approximately 5% of those infected with COVID-19 develop critical illness (Wang et al., 2020). Older adults have been heavily impacted: older adults aged 65 years and older make up 17% of the U.S. population, but 31% of COVID-19 infections, 45% of hospitalizations for COVID-19, 53% of intensive care unit stays for COVID-19, and 80% of COVID-19 deaths (CDC, 2021). Further breakdown by age is as follows: as of February 2021, according to the CDC, adults 55 years and older comprise 93% of COVID-19 deaths in the United States, adults 65 years and older comprise 81% of COVID-19 deaths, adults 75 years or older make up 60% of COVID-19 deaths, and adults 85 years or older make up 32% of COVID-19 deaths. The CDC (2021) has also identified that older adults are at a higher risk of infection, hospitalization, and death from COVID-19: the risk of COVID-19 infection for adults 65 years and older is 1-2 times greater than the risk for 5–17-year-olds, the risk of hospitalization is 40-95 times greater, and the risk of death is 1300-8700 times greater. In summation, infection, hospitalization, and death from COVID-19 disproportionately impact older adults. It is thus of great interest to further examine how COVID-19 manifests in older adults and its potential impact on those who survive it.

***Manifestations of the COVID-19 Infection in Older Adults***

Almost all systems of the body are impacted by aging, and, therefore, COVID-19 may present differently in older adults than it does in the general population. Differences in disease progression and symptoms have been observed for older adults infected with COVID-19 compared to the general population, as discussed below.

**Disease Progression.** A study of the median COVID-19 incubation periods—determined from the known point of contraction to initial symptom presentation—of 136 patients who contracted COVID-19 examined both younger adults (under 65 years old) and older adults (65 years or older). The median COVID-19 incubation period for younger adults was 7.6 days, compared to 11.2 days for older adults (Kong et al., 2020). After incubation, expert opinion asserts that disease progression may be more rapid for older adults, including the development of severe hypoxemia within a few hours (Cesari & Montero-Odesso, 2020). In terms of fatality, a cross-sectional observational study of 9807 older adults found that the fatality rate for COVID-19 increased with age; subjects aged 60-70 years had a 7.5% fatality rate, which increased to 26.2% for subjects 90 years and older (de Souza et al., 2020). Time from symptom onset to fatality differs for older adults as well: another study of 340 patients with COVID-19 found that the mean time from initial symptoms to death was 17.67 ± 12.85 days for adults aged 70 years and above, compared to 21.50 ± 9.18 days for adults under 70 years old (Gómez-Belda et al., 2020). Overall, older adults appear to have longer incubation periods, more rapid disease progression, higher fatality rates, and shorter mean times between initial symptoms and death due to COVID-19.

**Symptoms.** Many older adults present with common symptoms of COVID-19, but there have been some observed distinctions in symptom profiles for older adults. Firstly, older adults seem less likely to have some of the hallmark COVID-19 symptoms seen in the general population. A study of 340 patients compared the prevalence of common COVID-19 symptoms in older adults (aged 70 years or older) and non-older adults. Older adults had lower presentations of fever (51.3% versus 67.6%), dry cough (56.6% versus 68.6%), myalgia (23.7% versus 41%), and hyposmia (2.6% versus 13.8%) (Gómez-Belda et al., 2020). Other studies have also reported lower than typical rates of fever in older adults with COVID-19, especially in the frail (Nikolich-Zugich et al., 2020).

Older adults may also present with atypical symptoms not commonly seen in the general population. One of the symptoms consistently found in older populations infected with COVID-19 was delirium, also occasionally reported in the literature as the less intense "confusion." For example, Vrillon et al. (2020) reported that 71.1% of 76 patients aged 85 years or older presented with either confusion or delirium. Confusion was also observed by Gómez-Belda et al. (2021) in 19.9% of older adults with COVID-19, compared to 1.1% of younger adults with COVID-19. In a study of older adults 65 years and above in hospital settings, Zazzarra et al. (2020) also reported delirium in 38% of frail patients with COVID-19 and 12% of non-frail patients with COVID-19. This trend was further corroborated by a retrospective analysis that examined common complaints and health outcomes of 122 older adults aged 65 years or older (Gan et al., 2020). Subjects were classified into either a typical symptom group (60% of subjects) or an atypical symptom group (40% of subjects), and delirium was identified in 22% of the atypical group (Gan et al., 2020). Another pattern observed was the presence of muscle weakness; Vrillon et al. (2020) reported asthemia (notable muscle weakness and lack of energy) in 76.3% of patients aged 85 years and older, and Gan et al. (2020) reported decreased mobility and generalized muscle weakness in 36% of older adults with atypical COVID-19 symptoms.

Finally, the prevalence of falls in symptomatic older adults with COVID-19 is of particular interest. Nikolich-Zugich et al. (2020) identified that shortness of breath in older adults may present as a decline in function marked by impaired mobility or falls. This is supported by Vrillon et al. (2020), who found that 25.0% of older patients with COVID-19 were initially admitted due to a fall or reported a fall at the onset of COVID-19. Furthermore, Gan et al. (2020) reported that 36% of older adults with atypical COVID-19 symptoms complained of falls.

Finally, it should be noted that the presence of atypical COVID-19 symptoms in older adults is not always paired with a lack of typical symptoms—for instance, Gan et al.’s (2020) retrospective analysis found that 65% of older adults with atypical symptoms also had typical COVID-19 symptoms, such as fever (91%), cough (19%), and shortness of breath (13%).

Overall, although common COVID-19 symptoms can still appear in older adults, COVID-19 may present uniquely in older adults when compared to the general population. Symptoms associated with older adults include delirium, muscle weakness, and falls.

### ***COVID-19 Long-Haulers***

A growing number of reports identify that a portion of the patient population suffers from health issues even after recovering from COVID-19 infection (Raveendran, 2021). Collectively, these health issues are referred to as “long-haul COVID-19” (NICE, 2020). For the purposes of this literature review, a COVID-19 long-hauler is defined as someone who experiences symptoms four weeks or longer after contracting COVID-19, regardless of the severity of initial infection or the presence of symptoms in initial infection (NICE, 2020). Symptoms experienced in long-haul COVID-19 during these 4 or more weeks may overlap with acute COVID-19 symptoms or be new sequelae. A non-long-hauler is someone who contracted COVID-19 but does not experience symptoms lasting four weeks or longer (NICE, 2020). Currently known information about long-haul COVID-19 morbidity and duration, associations with long-haul COVID-19 development, symptoms, potential cognitive decline, and other considerations are discussed below.

**Morbidity and Duration of Long-Haul COVID-19.** Long-haul morbidity and symptom duration is difficult to accurately assess given the novelty of the long-haul COVID-19 phenomenon. These parameters are discussed together because long-haul COVID-19 diagnosis is based on symptom duration. Estimates of how many people with acute COVID-19 will develop long-haul COVID-19 vary in the literature; they are presented here from the largest to smallest estimates of morbidity. To begin, Carfi et al. (2020) assessed 143 subjects a mean of 60.3 ± 13.6 days after onset of COVID symptoms and found that 87.4% of participants reported the persistence of at least one symptom. Another study by Galván-Tejada et al. (2020) surveyed 78 control subjects and 141 patients who had recovered from COVID-19. Of those who had contracted COVID-19, 84.39% had a least one COVID-19 symptom fourteen days after testing negative for SARS-CoV-2 (confidence level 90%, margin of error 7%). For this group, symptoms persisted for an average of 31.23 days. In another study, patients were surveyed about their symptoms by telephone at COVID-19 onset (day 1) and 30 and 60 days later (Carvalho-Schneider et al., 2020). Two-thirds of the 130 participants surveyed reported symptoms at day 30 and day 60, and one third of participants reported still feeling ill or worse at day 60. Furthermore, a study by Xiong et al. (2020) compared the symptoms of 538 COVID-19 survivors with 184 control subjects using a telephone follow-up survey three months after recovering from COVID-19 infection. Focusing only on current symptoms separate from previous illnesses or other underlying conditions, it was found that 49.6% of the COVID-19 survivors had one or more general symptoms (overall discomfort, physical decline in strength, fatigue, sweating, myalgia, arthralgia, chills, limb oedema, or dizziness) three months after recovery. Most recently, a prospective observational cohort study examined 4182 users of the COVID Symptom Study app in the United Kingdom, United States, and Sweden (Sudre et al., 2021). An analysis of the participants' self-reported symptoms over time revealed that 13.3% developed long-haul COVID-19 (i.e., had symptoms lasting four or more weeks). Of those who became long-haulers, 33.9% experienced symptoms lasting at least 8 weeks, and 17.0% experienced symptoms lasting at least 12 weeks. Overall, estimates of the proportion of patients with acute COVID-19 that who will develop long-haul COVID-19 vary in the literature. From the current research available, it appears that long-haul COVID-19 can persist for at least 4-12 weeks.

**Associations with Long-Haul COVID-19 Development.** Several studies have searched for potential correlations between factors during acute COVID-19 infection and long-haul COVID-19 development. Sudre et al. (2021) established a significant correlation between age and the development of long-haul COVID-19: 21.9% of adults 70 years and older became long-haulers, compared to 9.9% of adults aged 18-49 years ($p < 0.0005$). However, Sudre et al. (2021) acknowledged that older adults were underrepresented in their sample of COVID Symptom Study app users. Nonetheless, this association with age is supported by Carvalho-Schneider et al. (2020), who correlated the age group of 40-60 years with long-haul COVID-19 development (odds ratios: 5.2-13.3). Carvalho-Schneider et al. (2020) also correlated prolonged symptoms with hospital admission at system onset (odds ratio: 2.8) and dyspnea during acute COVID-19 infection (odds ratio: 3.3) with long-haul COVID-19 development. These studies are contradicted by Townsend et al. (2020), who focused specifically on fatigue in COVID-19 survivors at least six weeks after the last observed COVID-19 symptom. No association was found between post-COVID fatigue and the days since symptom onset; the need for inpatient care, supplemental oxygen, or critical care; the length of hospital stay; or the values of leukocyte, neutrophil, and lymphocyte counts. This discrepancy may be explained by Townsend et al.'s (2020) exclusion of long-haul symptoms besides fatigue, whereas Carvalho-Schneider et al. (2020) and Sudre et al. (2021) also included symptoms such as fever, dyspnea, chest pain, and flu-like symptoms. Overall, age, hospital admission, and dyspnea during acute COVID-19 have been associated with the development of long-haul COVID-19.

**Long-Haul Symptoms.** Observed symptoms of long-haul COVID-19 can include symptoms of acute COVID-19 infection and new sequelae. One of the most common symptoms reported in long-haulers is fatigue. For instance, a study by Townsend et al. (2020) classified 128 post-COVID-19 patients into fatigued and non-fatigued groups based on the Chalder Fatigue Scale at least six weeks after the last observed COVID-19 symptom. Among these participants 52.3% of subjects surveyed met the criteria for fatigue. Xiong et al. (2020) also found that 28.3% of COVID-19 survivors reported physical decline or fatigue three months after being discharged from a COVID-19 hospitalization. This is further supported by Carfi et al.'s (2020) assessment of patients with COVID-19 a mean of 60.3 ± 13.6 days after symptom onset; 53.1% of the 143 subjects reported persistent fatigue. Another examination of 1733 discharged COVID-19 survivors by Huang et al. (2020) found similar results: after a median follow-up time of 186 days after onset of COVID-19 symptoms, 63% of recovered COVID-19 patients reported fatigue or muscle weakness. However, due to Huang et al.'s (2020) combination of "fatigue" and "muscle weakness" symptoms, this number may be an inaccurate reflection of patients who experienced fatigue.

Other trends in long-haul symptoms include disordered sleep. Huang et al. (2020) reported sleep difficulties in 26% of long-haulers, and Xiong et al. (2020) reported sleep disorders, difficulty falling asleep, and/or short/interrupted sleep in 17.7% of long-haulers. Another symptom found in multiple studies was joint pain, which was present in 7.6% of long-haulers 3 months after COVID-19 recovery (Xiong et al., 2020), and 27.3% of COVID-19 survivors assessed an average of about 2 months after symptom onset (Carfi et al., 2020). Less common long-haul symptoms include dypsnea, chest pain, myalgia, anxiety, and depression (Carfi et al., 2020; Huang et al., 2020; Xiong et al., 2020). Rare long-haul symptoms include hair loss, loss of taste, loss of smell, heart palpitations, decreased appetite, dizziness, diarrhea or vomiting, sore throat, skin rash, chills, limb oedema, sweating, headache, and fever (Carfi et al., 2020; Huang et al., 2020; Xiong et al., 2020). Overall, fatigue, disordered sleep, and joint pain appear to be common symptoms among COVID-19 long haulers.

**Potential Cognitive Decline in Long-Haul COVID-19.** Thus far, only one study has examined cognitive decline in long-haul COVID-19. Sudre et al. (2021) identified concentration or memory issues in 4.1% of COVID-19 long-haulers, as opposed to 0.2% of non-long-haulers ($p < 0.0005$). Though there is little other published evidence of cognitive decline in COVID-19 long-haulers, 33% of patients with severe COVID-19 demonstrated cognitive impairment at discharge, including inattention, disorientation, and poorly organized movements in response to command (Helms et al., 2020). Furthermore, experts theorize that long-term neurological effects of COVID-19 may arise from COVID-19's ongoing low-grade inflammatory response or the degeneration of functional neuronal and glial cells (Baig, 2020). A review of 12 autopsy studies performed on 135 deceased COVID-19 patients found COVID-19 RNA in the brainstem of 30 to

40% of the subjects. It is hypothesized that cognitive symptoms of long-haul COVID-19 may result from persistent brainstem dysfunction caused by damage during infection (Yong, 2021).

**Similar Phenomena in Other Diseases.** Long-term symptoms following resolution of initial infection are not novel to COVID-19. A similar "long-haul" phenomenon has been studied in survivors of Lyme disease, called PLDS (Post-Lyme-Disease-Symptoms). According to the Infectious Disease Society of America, PLDS is characterized by the onset and continuation or recurrence of fatigue, widespread musculoskeletal pain, or cognitive difficulties unexplained by other medical conditions at least six months after successful treatment of initial Lyme disease infection and resolution of its manifestations (Wormser et al., 2006). The most common symptoms experienced include fatigue, pain, impaired physical functioning, and cognitive impairment (specifically in the areas of memory and reaction time); other symptoms include radicular pain, dysesthesias, headache, arthritis, and hearing loss (Boršič et al., 2018; Fallon et al., 2008; Klempner et al., 2001; Krupp et al., 2003; Logigian et al., 1990). Like long-haul COVID, these conditions are not associated with lingering infection, but rather develop following recovery from Lyme disease (Fallon et al, 2008; Klempner et al., 2001; Krupp et al., 2003).

The global SARS outbreak of 2003 also left some patients grappling with long-term sequelae. A one-month follow-up of patients who had been discharged from hospital after surviving SARS infection demonstrated that survivors had lower proximal and distal muscle strength and worse scores on all domains of the SF-36 questionnaire (an assessment of physical functioning, bodily pain, role limitations due to physical health problems, role limitations due to personal or emotional problems, emotional well-being, social functioning, energy/fatigue, and general health perceptions) ($p < .05$) (Lau et al., 2005). Similar patterns were found in a one-year follow-up of SARS patients, who reported worsened physical functioning and general health (Hui et al., 2005), and a two-year study of SARS survivors, who demonstrated significant impairment in exercise capacity and health status (Ngai et al., 2010).

An important consideration in these other disease models is the impact of age. A multivariate analysis of treatment outcomes for Lyme disease at six months by Boršič et al (2018) revealed that the persistence of PLDS was associated with older adults aged 65 years and older, compared to younger adults aged 18-44 years (odds ratio of unfavorable treatment outcomes: OR 1.95 95% CI 1.14-3.32). Furthermore, in patients who survived SARS, age influenced quality of life ratings over time: adults above 40 years reported impaired quality of life levels up to twelve months post-infection, while adults under 40 years reached near-normal levels by six months post-infection (Li et al., 2006). For another infection, pneumonia, the presence of symptoms and quality of life impairment 28 days beyond infection was associated with older age and comorbidities, rather than persistent effects of pneumonia itself (el Moussaoui et al., 2006).

Overall, the presence of long-term syndromes in other disease models can offer insight into long-haul COVID, especially considering that older adults seem to be disproportionately affected.

**Other Considerations.** Experts have pointed to demonstrated physical and cognitive declines following recovery from critical illnesses, suggesting that similar declines may be seen in COVID-19 survivors (Heneka et al., 2020). For instance, notable decreases in muscular and cognitive function have been observed in older adults following hospitalization for critical illnesses including shock (traumatic, non-traumatic, and postoperative), severe sepsis, acute respiratory failure and other pulmonary insufficiency, severe hypotension, respiratory arrest, and cardiac arrest (Derde et al., 2012; Ehlenbach et al., 2010; Ehlenbach et al., 2015). Acute respiratory distress, which is often seen in COVID-19, has been associated with long-term cognitive dysfunction (Pandharipande et al., 2013) and long-term muscle weakness and fatigue (Herridge et al., 2003) as well. The same has been established for diseases that cause systemic inflammation such as rheumatoid arthritis, systemic lupus erythematosus, and multiple sclerosis (Maciel et al., 2018). Another consideration is the inability to determine if COVID-19 itself is the cause of long-haul symptoms. It is important to note that critically ill states, and even treatments for critical illnesses, may contribute to some of these long-term symptoms.

It is also important to consider that though development of long-haul COVID-19 has been correlated with advanced age, little research exists that focuses on long-haul COVID-19 in older populations. It is known that older adults are at greater risk for contracting COVID-19 and developing long-haul COVID-19. Because many of the systems affected by long-haul COVID-19 are instrumental in balance, one particular concern is that older long-haulers may notice detriments in balance or increased fall risk. Thus, it is of interest to examine what systems of the body are necessary for balance and how these systems are impacted by age. This can provide insight into whether age-related deficits in systems needed for balance may be worsened by long-haul COVID-19 in older adults.

## Balance and Fall Risk

### *Defining Balance and Types of Balance*

Balance is the process of controlling the body's center of mass with regards to its base of support. Static balance involves remaining still while restricting the body's center of mass to the bounds of its base of support. Dynamic balance refers to maintaining balance while moving (especially in gait), with the goal of moving the center of mass beyond the base of support, then re-establishing the base of support (Rose, 2010; Shumway-Cook & Woollacott, 2007; Spirduso et al., 2005). Perturbations to balance, if not adequately corrected, can result in a fall.

### *Systems of the Body that Aid in Balance*

Establishing and maintaining balance entails the synthesis of several critical systems: sensory perception, cognition, and motor control. Balance requires an accurate understanding of the body's position and movement relative to the environment, interpretation of this information, selection of a course of action, and smooth, timely execution of movement. Sensory perception provides information regarding how the body is positioned and/or moving relative to its environment. This is derived from the input of multiple sensory organs. For example, visual input from the eyes is prioritized in piecing together information about the environment and parts of the body that can be seen. Somatosensory input is also synthesized. For instance, cutaneous receptors responsible for detecting touch and pressure on the soles of the feet supply information about the characteristics of the loading surface and the load on each limb. Receptors such as Golgi Tendon Organs, muscle spindles, and joint proprioceptors provide information regarding how the body is positioned, as well as the direction and speed of bodily movement. Finally, the vestibular system provides information about the position and movement of the head relative to the body and whether the body or environment is moving (via the vestibulo-ocular reflex). All sensory input must then be synthesized by the central nervous system, which processes and evaluates various stimuli and determines the appropriate course of action. The motor system is responsible for the execution of this course of action, making the necessary adjustments to the body's position or movement either in anticipation of or reaction to center of mass displacement. Sensory, cognitive, and motor systems operate in tandem to continuously update, evaluate, and act with regards to the body's position in space (Rose, 2010; Shumway-Cook & Woollacott, 2007; Spirduso et al., 2005). Any disruptions to these systems worsen balance, increasing the risk of a fall.

## Aging, Balance, and Fall Risk

Understanding fall risk in older adults requires an understanding of how aging can impair balance-related systems. Due to the dangers of falls and the importance of balance in independent living, assessments that measure balance in older adults are valuable tools. Aging's impact on systems needed for balance will be discussed, followed by some of the methods used to assess balance ability for older populations.

### *The Effect of Aging on Systems of the Body that Aid Balance*

Balance deficits can arise from a wide variety of systems of the body impacted by aging. Some of these age-related changes are described below.

**Vision.** Aging is associated with a loss of visual acuity (the clarity or sharpness of vision) (Freeman et al., 2005), contrast sensitivity (the ability to distinguish objects from their background and distinguish between similar shades of light/dark) (Duggan et al., 2017; Sekuler & Hutman, 1980), and depth perception (the ability to visualize the world in three dimensions and determine how far an object is from the body) (Bell et al., 1972), as well as a narrowing of the visual field, particularly in peripheral vision (Williams, 1983). These changes, especially when compounded, lower the quantity and alter the quality of visual information received by the central nervous system. Integration of visual information with other sensory feedback may then be less efficient. Furthermore, if sensory perceptions are in conflict, visual information is prioritized (Deshpande & Patla, 2007)—thus, inaccurate visual information may lead to a distorted perception of the body in space.

**Somatosensation.** Incoming somatosensory input is also affected by aging. A decrease in number of innervating neurons causes reduced sensitivity to touch and pressure in cutaneous receptors. The speed and amplitude of nerve conduction of cutaneous receptors also decreases, reducing sensitivity (Shaffer & Harrison, 2007). At the cutaneous receptors found in the soles of the feet, this leads to decreased perception of the characteristics of the support surface, limb loading, and location of the center of mass with regards to the limits of stability. Aging is also associated with decreased sensitivity of other proprioceptors such as muscle spindles, Golgi Tendon Organs, and joint receptors (Shaffer & Harrison, 2007). This leads to difficulty in an appropriately scaling responses to perturbations to balance.

**Vestibular System.** Aging in the vestibular system is seen in a decrease in the number and size of vestibular neurons in hair cells (Sloane et al., 1989). The vestibulo-ocular reflex also deteriorates (Baloh et al., 1993). This means that older adults have more difficulty establishing the position and movement of their head relative to the rest of their body as well as more difficulty determining whether they or the environment is moving.

**Cognition.** Cognitive impairment with age can lead to compromised perception of incoming sensory feedback, inability to (consciously or unconsciously) select an appropriate response, and inability to implement the selected response. Complications in cognitive evaluation and processing may occur when different sensory systems provide conflicting input about the position and movement of the body. Cognitive processes are also shown to be slower in older adults, with marked deficits in attention and memory (Bowles & Poon, 1982; Madden, 2007; Morris & McManus, 1991). A decreased ability to multitask is also observed with aging (Allen et al., 2014), meaning it is more difficult for an older adult to cognitively process a balance or postural adjustment while distracted. Degradation of these cognitive functions increases fall risk in older adults.

**Motor System and Muscle.** Loss of motor neurons in the primary motor cortex and other areas of the central nervous system, a decrease in motor nerve conduction velocity, and a decrease in neurotransmitter levels at motor synapses have been demonstrated in older adults (Guo et al., 2021). This results in a decreased ability to communicate the desired movement to the muscles. Aging is marked by changes to the skeletal muscle as well. The number of fast twitch muscle fibers decreases with age, hampering an older adult's ability to produce adequate muscular power needed to respond to perturbations in balance (Evans & Lexell, 1995). Also of note is an observed decrease in muscular endurance, meaning that an older adult would fatigue more quickly, potentially increasing the risk of a fall (Carmeli et al., 2002). Overall, deterioration of skeletal muscle with age reduces capability to produce an adequate and timely force needed to correct disruptions to balance or stability.

### *Balance and Fall Risk Assessments for Older Adults*

Due to the deficits in balance seen with age, it is of interest to assess fall risk of older adults. Many field tests exist for this purpose. Their assessment can include static and/or dynamic balance, as well as basic and instrumental activities of daily living (ADLs). Basic activities of daily living are considered those necessary for human functioning and self-care, such as eating, bathing, dressing, and using the restroom. Instrumental activities of daily living are more complex activities required to function within a community, such as shopping, attending social engagements, or managing finances (Lawton & Brody, 1969). Determining fall risk and balance in terms of instrumental and basic activities of daily living is useful in assessing an older adult's ability to live independently and making practical decisions about levels of care and support for older adults (Rose, 2010). Explorations of the types of balance assessed by various field tests, including the Berg Balance Scale, Fullerton Advanced Balance Scale, and others are presented below.

**Berg Balance Scale.** Considered the gold standard for field assessments of balance, the Berg Balance Scale (BBS) is most commonly used with community dwelling older adults (Downs et al., 2013). In this test, 14 items are scored on a scale of zero to four by an administrator, based on the total time the subject can maintain balance or the degree of assistance they require to complete the task. A total score of 0-56 is then calculated, with higher scores indicating better balance. A strength of the BBS is its breadth of assessment; it includes both static and dynamic balance tasks and incorporates movements common to basic activities of daily living. For example, static activities of daily living assessed include standing unsupported and sitting with the back unsupported. Other tasks, although they may not be common in activities of daily living, provide further insight into the static balance capabilities of the participant. These include standing unsupported with the eyes closed, standing unsupported with the feet together, standing unsupported with one foot in front of the other, and standing on one leg. Considerable overlap with basic activities of daily living can be seen in the BBS's dynamic balance tasks as well. These items include moving from sitting to standing without using the hands, moving from standing to sitting, pivot transfers between chairs, and picking an object up off of the floor while standing. Dynamic balance is also further assessed in tasks such as reaching forward with an outstretched arm while standing, turning completely to look over the shoulder, turning 360 degrees, and placing alternating feet on a step or stool while standing. Overall, the BBS's inclusion of both static and dynamic balance measures results in a comprehensive assessment, and the representation of movements found in basic ADLs means the

BBS is more relevant to the day-to-day functional capabilities and independence of participants (Rose, 2010; Shumway-Cook & Woollacott, 2007; Spirduso et al., 2005).

**Fullerton Advanced Balance Scale.** The Fullerton Advanced Balance Scale (FABS) is another broad assessment of an older adult's balance ability (Duncan et al., 1990). It involves 10 test items scored from zero to four, based on factors such as the time a participant can maintain balance, the number of steps the participant must take to complete the movement, or assessment of form and postural adjustments made. The maximum possible score is 40 points, with a higher score indicating better balance. These ten test items assess both static and dynamic balance. Static balance tasks include standing with the feet together and eyes closed, standing on one leg, and standing on foam with the eyes closed. Some of the FABS's dynamic balance tests, like those of the BBS, replicate movements needed for basic activities of daily living. For example, participants step up on to an over a 6-inch bench, walk while turning their head, and react to a postural disturbance. In addition to these common motions, dynamic balance is also assessed by tasks such as reaching far forward with an outstretched arm to retrieve an object at shoulder height, turning 360 degrees to the left and right, tandem walking, and a two footed jump. Since some of these tasks, in particular balancing on foam, the two footed jump, and reacting to postural disturbance, are more difficult than those found in the BBS, the FABS is often recommended for use with more active older adults who may have better balance capabilities (Duncan et al., 1990). Overall, it provides a broad assessment of both static and dynamic balance abilities, including some movements found in basic activities of daily living.

**Other Field Tests.** Many other field tests are employed in the research literature to assess the fall risk of older adults. The next tests presented assess fewer elements of balance than the more comprehensive BBS or FABS. One such test is the Timed Up & Go (TUG) Test

(Nordin et al., 2006), which assesses dynamic balance: participants begin seated with their back against a chair back, and, when indicated, stand, walk three meters at a comfortable and safe pace, turn, walk back to the chair, and sit again while being timed. This time is then evaluated in comparison to normative or criterion reference standards. Despite its simplicity, the TUG test includes three key movements of daily living: transferring from sitting to standing, maneuvering comfortably about the home, and transitioning from standing to sitting. Another field test is the Functional Reach Test (Duncan et al., 1990), which evaluates an older adult's ability to reach forward with the arm flexed to 90º and the forearm extended, parallel to a yard stick at shoulder level. The distance the participant is able to reach without compromising balance is recorded and compared to established standards. Although its movement is not common to day-to-day activities, this test can be used to assess dynamic balance. A third field test measuring dynamic balance is the Functional Gait Assessment (FGA), which evaluates balance in gait and the participant's ability to perform other motor tasks while walking (Wrisley et al., 2010). The level of impairment is scored from zero to three during 10 walking conditions, for a maximum total of 30. A higher score indicates better dynamic balance and can be assessed in comparison to establish standards. Finally, the Four Square Step Test assesses dynamic balance by having participants step forwards, sideways, and backwards around a marked square grid on the floor (Moore & Barker, 2017). This movement requires coordination in changing directions and is scored based on time taken and ability to complete the movements.

Ultimately, data from any of these field tests can be evaluated against their respective normative or criterion reference standards to determine fall risk for older adults. However, their administration requires both the subject and proctor to be physically present in the same space. Not only does this limit the potential subject pool, but physical proximity may also be considered dangerous during a time of global pandemic—especially for high-risk older adults. Thus, it is of interest to determine other methods that balance and fall risk in older adults may be assessed. Nonetheless, it is important to understand these field tests, as their correlations with other methods can be used to establish concurrent validity.

**Self-Report Measures and Questionnaires**. Self-report measures are another method of assessing fall risk in older adults. Questionnaires—especially when administered online—can yield far greater sample sizes than in-person data collection allows. They also mitigate risk considerations in asking vulnerable populations (e.g., recently ill older adults) to perform tasks that they may find strenuous or difficult or come into contact with potential carriers of COVID-19. With this rationale in mind, two self-report questionnaires, the Activity-Specific Balance Confidence (ABC) Scale and the Fall Efficacy Scale International (FES-I), will be examined for their relevance in assessing balance and fall risk in older adults.

***Activity-Specific Balance Confidence Scale*.** The Activity-Specific Balance Confidence (ABC) scale is a sixteen-item self-report questionnaire. Rationale and context for its development will be provided, followed by a discussion of its criterion reference standards to determine fall risk, as well as its reliability and validity in various research applications.

<u>Development of the Activities-Specific Balance Confidence Scale and its Criterion or Values to Determine Fall Risk.</u> The ABC scale builds on previous work in measuring balance confidence and efficacy. It attempts to address some of the problems identified with an already existing self-report questionnaire, the Falls Efficacy Scale (FES) (Tinetti et al., 1990), while using the same core ideas to determine fall risk. The central concept of the original FES and the ABC scale is Bandura’s theory of self-efficacy (Bandura, 1997). According to Bandura, self-efficacy is the perception of one’s own ability with regards to a specific activity. Notably, one’s

efficacy regarding a task may or may not accurately reflect one's actual capability to successfully perform the task. Nonetheless, according to Bandura, a person's cognitive assessment of their ability will influence whether or not they engage in that activity (Bandura, 1997). In the development of the ABC scale, Powell and Myers (1995) apply this theory to fall risk assessment in older adults: they suggest that decreased self-efficacy regarding maintaining balance during specific tasks will lead to avoidance of those tasks. In turn, this avoidance will decrease physical ability and balance capability during such tasks, increasing fall risk. Thus, they argue that balance-related self-efficacy is important to measure when considering fall risk—even if the cognitive appraisals measured do not necessarily align with the subjects' actual ability. Of note, though, is the use of the word "confidence" in the ABC scale instead of "efficacy." Bandura (1997) distinguishes between the two: confidence refers to the strength of belief a person holds but does not always specify what this belief is about, whereas efficacy includes self-confidence and cognitive appraisal of ability to do a specific task. However, the type of confidence assessed by the ABC scale is "activity specific;" it applies the concepts of capability evaluation and strength of belief to very specific balance scenarios (Powell & Myers, 1995). Thus, the ABC scale is based around the core idea of measuring balance efficacy, not just confidence.

As previously stated, the ABC scale is not the first of its kind to assess balance efficacy in older adults via self-questionnaire. Rather, it was developed to address three criticisms of an existing scale, the Falls Efficacy Scale (FES) (Tinetti et al., 1990), while still retaining the central concepts (Powell & Myers, 1995). The FES asks subjects to rank on a scale of 1 to 10 how confident they are that they can do ten basic activities of daily living without falling (Tinetti et al., 1990). One critique of the original FES was that the item descriptors were too vague, potentially leading to differing interpretations. Thus, one goal of the ABC scales' development was to provide more detailed item descriptors, as increased specificity would better assess efficacy relating to balance per Bandura's definition. Another criticism the ABC scale tries to address is the potential ceiling effect for higher functioning older adults in the FES. The FES includes basic activities of daily living, such as dressing, bathing, getting in and out of bed, and walking around the house (Tinetti et al., 1990), which a higher-functioning older adult may not have balance struggles with. As such, another goal in the development of the ABC scale was to include a wider continuum of activity difficulty and include more instrumental activities of daily living to provide a more comprehensive assessment of an older adult's balance confidence while living independently in a community (Powell & Myers, 1995). Finally, the third element of the FES criticized is that it measures confidence that a participant could do the activity "without falling" (Tinetti et al., 1990). Developers of the ABC scale noted that losses of balance could occur that do not result in a fall. Thus, the third goal of the ABC scale's development was to reword the scoring question to include less-extreme losses of balance (Powell & Myers, 1995).

With these goals, the ABC scale's items were proposed and developed by 15 clinicians and 12 older adults (outpatients over the age of 65 years). Clinicians and outpatients were asked to generate a list of the most important activities essential to independent living that requires some change in position or walking and would be safe for most older adults. Older adults were also asked if they were afraid of falling during any normal daily activities and, if so, which. From these discussions, the ABC scale's sixteen items were constructed, keeping the criticisms of the FES in mind. To create a wider spectrum of difficulty and provide detailed scenario descriptions, several items on the original FES were modified for the ABC scale. For example, the "light housekeeping" item on the FES became the more specific "sweeping the floor" on the ABC scale. Other scenarios on the ABC scale expand on items from the FES to include more detailed descriptions, as well as varying levels of difficulty and safety. For instance, one item on the FES is “reaching into cabinets and doors” (Tinetti et al., 1990). In the ABC scale, the movement of “reaching” is separated into four distinct types: bending over and picking up a slipper from the front of a closet floor, reaching for a small can off a shelf at eye level, standing on tip toes and reaching for something above the head, and standing on a chair to reach for something (Powell & Myers, 1995). Such specificity in scenarios allows for a better determination of efficacy as defined by Bandura (1997). This is also seen in the variety of walking scenarios the ABC scale uses: walking around the house, walking up and down the stairs inside the home, walking outside of the house to a car parked in the driveway, walking up or down a ramp, and walking outside on icy sidewalks. Although the functional task (walking) is the same, each scenario specifies a type of walking with differing challenges to dynamic balance. Additionally, the instrumental activity of daily living defined by the FES as “light shopping” (Tinetti et al., 1990) is split into specific components of the activity on the ABC scale, again with varying difficulty levels. “Shopping” related items on the ABC scale include some transportation and locomotion scenarios, such as getting into or out of a car, walking across a parking lot to the mall, walking in a crowded mall where people rapidly walk towards them and pass by, walking through the mall with people bumping into them as they walk by, stepping onto or off of an escalator while holding onto the railing, and stepping onto and off of an escalator while holding parcels such that the railing cannot be held (Powell & Myers, 1995). Overall, the items in the ABC scale are designed to include detailed descriptions of both basic and instrumental activities of daily living that range in difficulty level. The resulting sixteen items describe familiar scenarios that require dynamic balance in day-to-day community living. For each of these items, participants are asked to rate their percent confidence (from 0% to 100%) that they would not feel unsteady or lose their balance during that scenario. This wording achieves the aforementioned goal of including losses in balance that do not necessarily result in a fall. The total score is calculated by finding the average percent confidence given, or the sum of all scores divided by the total number of items. As such, the final score can range from 0%-100%, with higher scores indicating greater activity-specific balance confidence (Powell & Myers, 1995).

Criterion Standards to Determine Level of Functioning and Fall Risk for the ABC Scale. Once completed, a participant's score on the ABC scale may be compared to established criterion standards. Developed by Myers et al. (1998) following an examination of various studies that had implemented the ABC scale, the criterion or cut off values for levels of functioning and fall risk, as well as their rationale, are described as follows. Firstly, Myers et al. (1998) identified that an aggregate ABC score of 50% or below indicates a low level of functioning. When the ABC scale was introduced, Powell & Myers (1995) examined sixty community-dwelling older adults aged 65 years to 95 years old. The older adults were classified as having high or low mobility confidence based on their perceived need for walking aids and physical assistance walking outdoors. The "low" mobility confidence group had an average gait speed of less than 0. 5 m/s and scored an average of 38 % on the ABC scale. Furthermore, another study that implemented the ABC scale with 475 older adults demonstrated that individuals who required home care had the lowest ABC scale scores, with a mean score of 35.8 ± 17.9 %, and TUG test scores (mean 21.6 ± 4.5 seconds) that indicate a high fall risk (Myers et al., 1996). Overall, Myers et al. (1998) determined that individuals who scored less than or equal to 50% on the ABC scale had mobility limitations that classify them as having a low level of functioning. On the other hand, Myers et al. (1998) determined that scores of 80% or higher indicate a high level of functioning. In the ABC scale's introductory study (Powell & Myers, 1995), the “high” mobility confidence group—older adults who did not need assistive walking devices or physical help walking outdoors—had a mean ABC scale score of 80.9 ± 16.6 %. Furthermore, Myers et al.’s (1996) study of older adults, including some in exercise groups, found that older adults who perceived themselves as highly physically active had a mean ABC scale score of 89 ± 12 %, whereas those who identified as “not at all physically active” scored, on average, 74 ± 26 %. From this literature, Myers et al. (1998) determined that older adults who score 80% or above on the ABC scale tend to be highly functioning and already physically active. For the same reasons, they classified adults who scored between 50% and 80% as having a moderate level of functioning.

Another study that used the ABC scale also determined a cut-off value to determine fall risk. Lajoie & Gallagher (2004) measured reaction time, postural sway, BBS scores, and ABC scale scores in 45 older adults classified as “fallers” (i.e., those who sustained one or more falls in the previous year) and 80 older adults classified as “non-fallers” (i.e., those with no falls within the previous year and could walk without a mobility aid). Based on these groups, they analyzed ABC scale scores using logical regression to identify fall risk. They found that a cut-off score of below 67% indicated substantial risk of falling, with a sensitivity of 84.4% and specificity of 87.5%. With these values in mind, the reliability and validity of this scale will next be discussed.

Reliability and Validity of the ABC Scale. The ABC scale has been established as a reliable and valid questionnaire. The introductory study by Powell & Myers (1995) determined that the ABC scale demonstrated strong test-retest reliability, with highly stable scores ($r = 0.92$, $p < 0.001$) for 21 subjects over a two-week period. The same study found strong internal consistency reliability for the ABC scale (Cronbach’s alpha = 0.96). Another study of 174 community-dwelling adults over 60 years of age by Huang & Wang (2009) also determined high internal consistency validity (Cronbach's alpha = 0.96) for the ABC scale. This high degree of internal consistency found for the ABC scale indicates that the sixteen items of the scale measure the same underlying construct.

Literature using the ABC scale has also demonstrated various aspects of its validity. To begin, the ABC scale's introductory study (Powell & Myers, 1995) established the scale's discriminant construct validity. Older adults were classified into low and high mobility confidence groups based on their perceived need for mobility devices and physical assistance to walk outdoors. Both the FES and the ABC scale were able to distinguish between these two groups, but the ABC scale had a larger effect size (1.5 for the ABC scale compared to 1.2 for the FES) (Powell & Myers, 1995). Lajoie & Gallagher (2004) also established that there was a significant group difference between the ABC scale scores of fallers and non-fallers ($F(1,123) = 132$, $P < 0.01$), with the average score being 48% and 85%, respectively.

In addition, literature using the ABC scale demonstrates stable associations between the ABC scale and various field tests of balance for older adults. For instance, the criterion validity of the ABC scale was determined by correlating its scores to those of the Berg Balance Scale, as in the study by Lajoie & Gallagher (2004). This examination of 45 "faller" and 80 "non-faller" older adults found a very strong correlation ($r = 0.81$, $p < 0.01$) between the ABC scale and the BBS. This was corroborated by two other studies: first, Talley et al. (2008), which examined 213 noninstitutionalized women aged 70 years and older using the ABC scale, BBS, TUG test, and measures of gait speed, fall history, and assistive device use. A moderate correlation between ABC scale scores and BBS scores ($r = 0.57$, $p < 0.01$) was found. Second, Hatch et al. (2003) assessed 50 community dwelling older adults between the ages of 65 to 95 years using the ABC scale, BBS, and TUG test. A strong correlation between the ABC scale and the BBS was demonstrated (r = 0.752, $p < 0.01$), and step-wise regression analysis found that BBS scores accounted for 57% of the variance in ABC scale scores. Furthermore, concurrent validity for the ABC scale has been established via comparisons with the TUG test in the literature. For example, the previously discussed studies found moderate to strong correlations with the TUG test in noninstitutionalized women over 70 years (r = -0.39, p < 0.001) (Talley et al., 2008) and community-dwelling older adults (r = 0.698, p < 0.01) (Hatch et al., 2003). Further concurrent validity was established in Wrisley and Kumar's 2010 examination of the Functional Gait Assessment (FGA) test in 35 older adults between 60 and 90 years of age. It was found that the ABC scale had a moderate correlation with the FGA test (r = 0.53, $p < 0.01$).

Furthermore, a study by Rolenz et al. (2016) is of particular relevance concerning older adults who may be experiencing long-haul COVID-19. Rolenz et al. (2016) examined whether mild cognitive impairment affected the ability of the ABC scale to identify fallers and non-fallers. A sample of 62 older adults 65 years and older was divided into a group of "fallers" (those who had two or more falls in the past year) and "non-fallers" (those who had no falls in the past year. Cognitive impairment was assessed using the Montreal Cognitive Assessment, which determined whether subjects were considered to have mild cognitive impairment (MCI) ($n = 41$) or not ($n = 21$). The ABC scale was able to discriminate between fallers and non-fallers in the total sample, those with MCI, and those without MCI with sensitivity values of 89.2%, 87.5%, and 92.3% and specificity values of 56.0%, 58.8%, and 50.0%, respectively. Furthermore, the ABC scale was correlated with the TUG test for both subjects with MCI (r = 0.92, $p < 0.01$) and without MCI (r = 0.85, $p < 0.01$). Overall, this study demonstrates discriminant and concurrent validity of the ABC scale with these groups, indicating that it is suitable for use with long-haulers with mild cognitive impairment.

Overall, literature shows a consistent pattern of correlation between the ABC scale and field tests of balance and fall risk. These associations strengthen the case for the ABC scale's use in determining fall risk via self-report questionnaire.

Summary. Ultimately, the ABC scale measures the activity-specific confidence of older adults for sixteen dynamic balance tasks in accordance with Bandura's theory of self-efficacy. Its items are well-detailed, specific, include basic and instrumental activities of daily living, and encompass a range of task difficulty. Scores on these items can be averaged and compared to criterion standards indicating level of functioning and fall risk, as determined in the literature. Literature has also demonstrated the ABC scale's reliability, discriminant validity, and concurrent validity, establishing a trend of stable association between the ABC scale and some of the previously discussed field tests for balance and fall risk assessment.

***Falls Efficacy Scale—International.*** The Falls Efficacy Scale—International (FES-I) is another self-report questionnaire designed for use in older populations. Rationale and context for its development will be provided, followed by a discussion of its criterion or cut off reference standards to evaluate fall risk, as well as reliability and validity in various research applications.

Development of the Falls Efficacy Scale—International and its Criterion Reference Standards for Fall Risk Assessment. The FES-I was developed by the members of the Prevention of Falls Network Europe to measure balance and fall concerns in older adults (Yardley et al., 2005). As the scale was based on the original Falls Efficacy Scale, its developers maintained "FES" in the name of the FES-I to indicate its origins. However, the FES-I itself was not designed to measure efficacy, but rather an older adult's concern about falling regarding various scenarios (Yardley et al., 2005). Nonetheless, the scale's rationale is based on a similar application of Bandura's theory of self-efficacy (1997). Yardley et al. (2005) argue that it is valuable to measure concern about falling because it may lead to avoidance of tasks that promote concern. In turn, this avoidance may decrease physical mobility and balance ability. In addition, the FES-I was also developed to address several critiques of the original Falls Efficacy Scale (FES) and the ABC scale (Yardley et al., 2005). Firstly, previous questionnaires include items that do not universally apply to the day-to-day lives of older adults around the world. For instance, items involving walking to or getting in and out of a car were criticized because not all older adults have access to cars, and, in some areas, it is not even a primary mode of transportation. Similarly, the ABC scale's use of a shopping mall as a location for scenarios (Powell & Myers, 1995) was also criticized, as shopping malls are not ubiquitous throughout the world. Thus, one of the primary goals in the development of the FES-I was modification of item language to make the scale more suitable for translation and use across different cultural contexts (hence the "International" in its name). This is needed so that participants from a broad range of sociocultural backgrounds can easily understand and identify the task each item presented. Ensuring that each item has consistent interpretations across use strengthens its validity and applicability in an international context. Another goal in the development of the scale was the addition of relevant items that present more demanding balance challenges to older adults (Yardley et al., 2005). Like the ABC scale, the FES-I attempts to address the ceiling effect of the original FES. A broader range of task difficulty or item difficulty would increase the FES-I's applicability to older adults at a higher level of functioning and those who are not challenged by basic activities of daily living. The third goal in the development of the FES-I was the inclusion of social activities in the scale's items. Yardley et al. (2005) wanted to acknowledge that fear of social embarrassment contributes to activity avoidance, and thus wanted to evaluate the impact of a fear of falling on the social life of participants. In addition, another goal in the development of the scale was an adjustment in how participants rate each activity. Yardley et al. (2005) criticized the ABC scale's use of percent confidence, indicating that it may be difficult for an older adult to distinguish between, for example, 30% and 40% confidence. Thus, developers wanted a simpler method of ranking each item with less ambiguous increments.

Working from these goals, members of the Prevention of Falls Network Europe began with the original FES scale as a template. Several of the FES's basic activities of daily living were maintained in the FES-I, such as getting dressed and undressed, preparing simple meals, taking a bath or shower, getting in and out of a chair, and going up or down stairs (Yardley et al., 2005). The FES-I also maintains some of the original FES's instrumental activities of daily living, including cleaning the house and going to the shop. However, the FES's assessment of reaching was determined to lack broad applicability: the FES item in question, "reaching into cabinets or closets," does not account for differing systems of storage throughout cultures. Therefore, this item was changed to "reaching up or bending down" to better convey the intended movement (Yardley et al., 2005). Another item adjusted for broader cultural relevance was the ABC scale's "walking outside on icy sidewalks" (Powell & Myers, 1995). Wanting to recognize the balance challenge and fear of falling older adults have in such situations, while also acknowledging that ice on a sidewalk may not occur in certain environments, this item was changed to "walking on a slippery surface" (Yardley et al., 2005). The addition of this item also represents the inclusion of more greatly demanding balance tasks. Other FES items were also adjusted to indicate a more difficult task, such "answering the telephone." This item is presented on the FES-I as "going to answer the telephone before it stops ringing" (Yardley et al., 2005).

Adding a timed element to the task increases its difficulty level and potential balance challenge. Like the ABC scale, the FES-I also expands on the original FES's walking item to include a greater spectrum of difficulty. Walking-related items on the FES-I include: walking around the neighborhood, walking in a place with crowds, walking on an uneven service, and walking up and down a slope (Yardley et al., 2005). Distinct from both the FES and ABC scale, however, is the inclusion of two items that specifically involve a social element: visiting a friend or relative and going out to a social event. The purpose of these items is to evaluate how social life is affected by a fear of falling. In this way, Yardley et al. (2005) attempt to account for activity avoidance that may result from a social embarrassment, rather than purely the fear of losing balance itself. Altogether, the FES-I presents 16 items that assess dynamic balance in instrumental and basic ADLs. In response to each scenario, subjects rate each activity on a scale of one to four based on how concerned they are about falling if they perform that activity. In this scale, a score of 1 indicates "not at all concerned," 2 indicates "somewhat concerned," 3 indicates "fairly concerned," and 4 indicates "very concerned" (Yardley et al., 2005). This method addresses the goal of creating a simpler and less ambiguous scoring system. Using this scale decreases the number of options participants must choose from and provides clear levels of concern for each number.

Once participants have indicated their level of concern for each item, the scale is scored by summing the scores for each item, yielding a range of 16 to 64 (Yardley et al., 2005). A higher score indicates a greater concern about falling, and individual scores may be compared to criterion values established by Delbaere et al. (2010). Delbaere et al. (2010) measured instances of previous falls, balance sway, and FES-I scores in 500 community-dwelling older adults between the ages of 70 and 90 years. In order to identify cutoff points, ROC plots were created comparing the scale with balance sway assessment (area under the curve = 0.58) and instances of previous falls (area under the curve = 0.67), with the goal of determining the best tradeoff between sensitivity and specificity. From this analysis, the following criterion values were determined: a score of 16 to 19 indicates a low concern for falling, 20 to 27 indicates a moderate concern for falling, and 28 to 64 indicates a high concern for falling (Delbaere et al., 2010). With this background in mind, the reliability and validity of the scale will be examined.

Reliability and Validity of the FES-I. The FES-I's introductory study (Yardley et al., 2005) administered the scale to 704 older adults above the age of 60 years from a wide variety of cultural backgrounds. An examination of the study's internal reliability yielded a Cronbach's Alpha of 0.96, indicating that the scale's items measure the same central concept. Furthermore, when 16 of the original participants were retested one week later, the intraclass correlation coefficient between the first and second scores was 0.96. This strong test-retest reliability demonstrates the FES-I's stability over time.

Yardley et al.'s (2005) introductory study also determined the discriminant construct validity of the FES-I. When subjects were divided into groups of fallers (one or more falls in the past year) and non-fallers (no falls within the past year), a significant difference ($p < 0.01$) was found between the scores of fallers (mean 35.45 ± 12.79) and non-fallers (mean 26.94 ± 10.78). Discriminant validity was further established by Delbaere et al. (2010) among 500 community dwelling older adults between 70 and 90 years of age. A significant difference ($p < 0.001$) between FES-I scores of fallers (mean score 26.1 ± 7.4) and non-fallers (mean score 22.1 ± 6.1) was determined. These results indicate that the scale may be used to distinguish between older adults who have fallen and older adults who have not. Furthermore, in the same study, a 12-month follow-up of 463 of the original participants revealed that their baseline scale score was able to distinguish whether or not they would become fallers, demonstrating the FES-I's predictive validity. This finding is significant because it indicates that the scale is a potential tool for assessing risk of future falls in older adults.

Other literature using the FES-I also reveals a pattern of association between the scale and field tests that measure balance, establishing both criterion and concurrent validity. For example, Dhaval et al. (2020) studied 100 older adults aged 60 years to 80 years who lived independently in the community with or without use of an assistive mobility device. Administration of the FES-I, the BBS, and the FABS demonstrated moderate concurrent validity between the FES-I and BBS (r = -0.62, $p < 0.0001$) and between the FES-I and the FABS (r = -0.48, $p < 0.0001$). Correlation with the BBS was further corroborated in a study of 50 stroke patients above the age of 40 years by Khan et al. (2015). For this population, a moderately strong correlation between the FES-I and BBS was established (ICC = -77%, confidence interval 95%). Another study of 42 patients whose balance had been affected by spinal cord injury (mean age 49.3 ± 11.5 years) demonstrated a strong correlation between the BBS and the FES-I (r = -0.81, $p < 0.01$), suggesting that patients who had a better ability to balance showed less concern with regards to falling (Wirz et al., 2010). The previously mentioned study of Parkinson's disease patients (Mehdizadeh et al., 2018) also established strong correlation with the BBS one hour after patients had taken medication (r = -0.71, $p < 0.001$) and 12 hours after medication had been taken (r = -0.70, $p < 0.001$). Furthermore, a moderate association was also established between the FES-I and the FRT one-hour post-medication (r = -0.51, $p < 0.001$) and 12 hours post-medication (r = -0.56, $p < 0.001$). Overall, literature demonstrates a trend in FES-I use that suggests its scores are correlated with those of field tests for balance and fall risk. This consistent association indicates that, even though the scale measures concern for falling, it aligns with other measures of balance and fall risk. It may also be used to discriminate between fallers and non-fallers.

Summary. Ultimately the FES-I is established as a reliable and valid method of determining concern about falling in older adults, specifically with the intent to be applicable to a broader range of sociocultural contexts and to include objects that present a greater balance challenge. Its items assess dynamic balance and a variety of basic and instrumental tasks of daily living with established criterion values for fall-related concern.

**Conclusion**

In summation, the COVID-19 pandemic disproportionately affects older adults in the United States and globally. COVID-19 can also manifest differently in older adults; trends in the literature show an increased prevalence of delirium and muscle weakness in older adults when compared to the general population with COVID-19. Even after recovery from SARS-CoV-2 infection, there is a chance of developing long-haul COVID-19. Preliminary research has correlated older age with development of long-haul COVID-19, meaning that it is of particular interest to examine its manifestations in older adults. In addition to vulnerability to long-haul COVID-19, older adults are more vulnerable to falls due to decreased balance ability. Maintaining balance requires the synthesis of sensory, cognitive, and motor systems in the body; any impairments to these systems will decrease balance ability. The natural process of aging results in deficits to these systems, placing older adults at greater fall risk. Emerging literature also identifies that long-haul COVID-19 may affect these systems. For instance, fatigue may compromise the motor system's ability to adequately correct for balance perturbations, and potential cognitive impairment in long-haul COVID-19 may hinder an older adult's ability to synthesize information and generate movement plans. In essence, symptoms of long-haul

COVID-19 may compound the aging-related declines in systems needed for balance and, thereby exacerbate fall risk in older adults who experienced or are experiencing long-haul COVID 19. Therefore, it is of interest to examine the balance-related manifestations of long-haul COVID-19 in older adults.

# **Appendix B:** Journal of Aging and Physical Activity Author Guidelines

Authorship Guidelines

The Journals Division at Human Kinetics adheres to the criteria for authorship as outlined by the International Committee of Medical Journal Editors*:

Each author should have participated sufficiently in the work to take public responsibility for the content. Authorship credit should be based only on substantial contributions to:

a. Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND
b. Drafting the work or revising it critically for important intellectual content; AND
c. Final approval of the version to be published; AND
d. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conditions a, b, c, and d must all be met. Individuals who do not meet the above criteria may be listed in the acknowledgments section of the manuscript.
*http://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html

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Manuscript Guidelines

The *Journal of Aging and Physical Activity* (*JAPA*) consists of three peer-reviewed sections: Original Research, Scholarly Reviews, and Professional Applications. The Original Research section contains scientific studies and investigations, systematic clinical observations, and controlled case studies. The Scholarly Reviews section publishes reviews that synthesize research and practice on important issues in the study of physical activity and aging. Articles based on experience in working with older populations and the available scientific evidence that focus on program development, program activities, and application of exercise principles are appropriate for the Professional Applications section. *JAPA* also includes an editorial section for exchange of viewpoints on key issues affecting physical activity and older adults.

Questions?

Most submission inquires can be addressed by reading the guidelines below. However, if you have questions not covered here, contact us.

Format

In preparing manuscripts for publication in *JAPA*, authors should adhere to the guidelines in the *Publication Manual of the American Psychological Association* (7th edition, 2020) unless otherwise noted in these submission guidelines. Copies of the APA Publication Manual can be found in most university libraries or purchased online through the APA website. Please note that the APA guidelines particularly require that authors acknowledge the existence of similar publications so that the Editor can "make an informed judgment as to whether the submitted manuscript includes sufficient new information to warrant consideration." If similar publications exist, please address this in your cover letter and provide a brief explanation of how the submitted manuscript adds to the literature. Manuscripts that do not conform to APA guidelines and to the guidelines described here may be rejected without review.

Please upload a Title Page as a separate document. This page should include the manuscript title, names of authors and institutional affiliation(s), suggested running head, and full mailing address, email address, and telephone and fax numbers of the corresponding author. The manuscript itself should not contain any author-identifying information and should be uploaded as the Main Document. Within the Main Document, the first page of the manuscript should contain only the title of the article. Page 2 should contain the abstract, with the text of the manuscript beginning on page 3. All manuscripts must include an unstructured (no headings) abstract of 100–150 words. Beneath the abstract, please also include 3–5 keywords not included in the title. The manuscript must be double-spaced, including the abstract, references, and any block quotes. Include line numbers that restart on each page of the manuscript (through Page Setup in Microsoft Word). Every effort should be made to see that the manuscript itself contains no clue to the author's identity. Please also include, when relevant, a statement regarding compliance with regulations for the use of human subjects. This will include a statement in the method section that prior to recruitment approval was obtained from an institutional/regional/national research ethics committee (while keeping the author's instiution blinded), and that all participants provided written informed consent.

*JAPA* does not impose limits for word count (outside of the 150 word limit for abstracts) or page count. However, authors should be concise in their writing. Information provided in tables and figures should be self-explanatory without referring to the main text, and should not duplicate information provided in the text. *JAPA* is able to publish supplementary material online alongside the journal article. Supplementary material must be referred to in the main document and uploaded as a separate file to be included in the peer-review process. However, supplementary material is not included in the copy-editing process and so the author retains responsibility for the content and presentation of the material.

The *JAPA* Editorial Board are in agreement with the APA style manual that the term "the elderly" is no longer an appropriate label for older adults, as it can be viewed as pejorative and is stereotypical. Instead, please refer to your sample as older adults or even more appropriately, by the specific age range. Similarly, *JAPA* is striving for a more positive approach to aging. Consistent with theories of aging, we discourage the "aging as decline" approach in favor of how older adults adapt to a changing physical, social, and cognitive landscape. We ask you to consider this more positive approach in writing your manuscript. Also note that *JAPA* uses the term “participants” and not “subjects” to refer to adults who have taken part in a study.

Specific Study Designs

**Clinical trials.** Manuscripts reporting clinical trials are required to follow the CONSORT guidelines and include a CONSORT flow diagram (figure). The International Committee of Medical Journal Editors (ICMJE) defines a clinical trial as follows: “any research project that prospectively assigns people or a group of people to an intervention, with or without concurrent comparison or control groups, to study the relationship between a health-related intervention and a health outcome” (2019, page 13). Health-related interventions are defined as those used to modify a biomedical or health-related outcome including physical activity interventions. Health outcomes are defined as any biomedical or health-related measure obtained from participants, including pharmacokinetic measures, psychological outcomes, and adverse events (ICMJE 2019). It is recommended that a clinical trial is registered in a public repository at the beginning of the research process (prior to participant enrolment). Trial registration numbers should be included at the end of the abstract with full details in the methods section. The registry should be publicly accessible at no charge, open to all prospective registrants, and managed by a not-for-profit organization. For a list of registries that meet these requirements, please visit the WHO International Clinical Trials Registry Platform. The registration of all clinical trials facilitates the sharing of information and enhances public confidence in research. In addition, if authors have not yet published their trial protocol, we encourage authors to include their trial protocol to be published alongside their main trial outcome paper as online supplementary material (on the understanding that there are no copyright restrictions). We also encourage authors to consult the TIDiER checklist for improving the transparency of intervention descriptions (https://www.equator-network.org/reporting-guidelines/tidier/).

**Systematic reviews.** It is recommended that authors have their systematic review protocol publicaly available in a register such as PROSPERO prior to analysis. Authors are also encouraged to use the PRISMA statement and checklist for transparent reporting of systematic reviews and meta-analyses. In addition, *JAPA* welcomes other types of review articles (narrative, scoping, and rapid, etc.) as long as they provide a novel contribution to the literature (e.g., new theoretical advance or synthesis).

**Qualitative studies.** *JAPA* is a multidisciplinary journal and its Editorial Board recognizes that qualitative research reflects a variety of epistemological traditions. Therefore, it is not mandatory for authors to adhere to a particular checklist when submitting qualitative journal articles to *JAPA*. Nonetheless, *JAPA* expects a basic standard of reporting that is consistent with international norms that are outlined below.

At a minimum, researchers should include statements in their manuscript outlining a theoretical framework, describing the theoretical basis for methods to be used, the research aims, respondent sampling and defending the rigor and trustworthiness of their analyses. Evidence of rigor and trustworthiness can be shown by authors through a range of practices illustrated in the following non-exhaustive list: use of a detailed methods section explaining the “researcher-as-instrument” or acknowledgement of reflexivity / positionality (researcher acknowledges, reflects and embraces their personal biases and details the process they undertook), a secondary coder (or "critical friend") to discuss your coding process and analysis, presentation of exemplar / key informant quotations, discussion of negative, atypical or contrasting cases, providing evidence of data saturation, use of triangulation, and clear depictions of coding processes. We also encourage authors to consider the reader when composing a qualitative or mixed methods manuscript and write with clarity and a central message in mind. Finally, while accepting that qualitative reports often employ small samples and focus on in-depth analyses of highly contextual and lived experiences, we expect authors to clearly articulate the theoretical contributions of their research, as well as wider social, geographic, policy, or economic related implications of their findings.

Artwork and Table Instructions

All figures should be in a separate file and not in the main document (one file for each). All tables are to appear at the end of the Word document after the reference list. Format tables in the table function of your word processing program rather than aligning columns in text with tabs and spaces or using text boxes. When creating tables, the size and complexity should be determined with consideration for its legibility and ability to fit the printed page.

All art must be professionally prepared, with clean, crisp lines; freehand or typewritten lettering will not be accepted. If photos are used, they should be black and white, sharply focused, and show good contrast. Each figure and photo must be properly identified. In graphs, use black and white or gray shading only, no color. Keep labels proportionate with the size of the figures on the journal page, which is 6.5 in. wide. Digital images should be 300 dpi at full size for photos and 600 dpi for line art. Any images where an individual is identifiable must have their identity concealed (e.g., blurring of the face) along with confirmation that it is not an image taken from a study participant or that the participant has provided written informed consent.

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Peer Review

Manuscripts are read by the Editor and/or an Associate Editor and, when possible, by at least one member of the Editorial Board and one or two additional reviewers. The review process is expected to take 6–12 weeks. There are no page charges to contributors. Manuscripts are evaluated through blind review.

All submissions should show evidence of good scholarship, judged by the explanation and rationale for the study, topical relevance and interest to the readership, the design and conduct of the project, and the presentation and discussion of results. Manuscripts that are judged as failing to meet these initial criteria may be rejected by the Editor without further review.

Before Submitting

Manuscripts must not be submitted to another journal at the same time. Public posting of a study protocol, including a brief (<500 words) summary of its results into a trial registry or pre-print server will not be considered prior publication. *JAPA* will also accept submissions of full papers that have been posted on pre-print servers. With any public posting, please include the DOI for the pre-print or weblink to the protocol in the *JAPA* submission form. Authors should not post an updated version of their paper on the pre-print server while it is being peer-reviewed for possible publication in the journal. If your paper is accepted, you must include a link on your preprint to the final version of your paper.

Authors are advised to check very carefully the typing of the final copy, particularly the accuracy of references, and to retain a duplicate copy to guard against loss. Authors are also encouraged to create and keep current an ORCiD personal identifier.

Authors of manuscripts accepted for publication must transfer copyright to Human Kinetics, Inc. This transfer of copyright form will be provided to authors upon submission.

## Appendix C: WWU IRB Informed Consent

**<u>Western Washington University Informed Consent</u>**

**Balance Confidence and Fall Risk in Older Adults with Long-Haul COVID-19**

We are asking you to be in a research study. Participation is voluntary. The purpose of this form is to give you the information you will need to help you decide whether to participate. Please read the form carefully. You may ask questions about anything that is not clear. When we have answered all your questions, you can decide if you want to be in the study or not. This process is called "informed consent."

**Purpose and Benefit:**

This research aims to examine the effects of long-haul COVID-19 on the balance confidence and fall risk of older adults. The effects of the new phenomenon of long-haul COVID-19, also called "Long COVID" or "Post-Acute COVID Syndrome" (PACS), are not yet fully understood. This study will increase our current understanding of how long-haul COVID may impact balance or risk of falling during daily activities for older adults.

**Participants should understand that:**

- To be eligible for this research, participants should:
    - Be between the ages of 60 years and 90 years
    - Live in the United States
    - Know their status of prior or current COVID-19 infection as confirmed by a positive or negative COVID-19 test
    - Participants currently experiencing COVID symptoms should know approximately how long they have had symptoms
- Participants will complete a series of demographic questions regarding age, gender, comorbidities, status of prior COVID-19 infection, severity of prior COVID-19 infection, and current long-haul COVID-19 condition.
- Participants will complete two questionnaires online that ask questions about balance confidence and concern about falling during various daily activities. In total, participation will take twenty to thirty minutes.
- There are minimal risks from participation in this research. Participants may experience some fatigue while taking the surveys and are encouraged to take small breaks as needed. If you do not wish to answer any of the questions asked, you may exit the survey at any time and your data will be discarded.
- Participants should understand that there are no potential benefits to you directly from your participation in this study.

- Your name and contact information are not collected with this survey.
- Your participation is completely voluntary. You are able to stop at any time you are taking the survey by exiting the survey.
- You may print a physical copy of this informed consent form for your records at any time.

This research is conducted by Mariel Relyea under the supervision of Dr. Harsh Buddhadev. Any questions that you have regarding the study or your participation may be directed to Mariel Relyea at relyeam@wwu.edu or Dr. Harsh Buddhadev at buddhah@wwu.edu.

If you have any questions about your rights as a research participant, you can contact the WWU Office of Research and Sponsored Programs (RSP) at compliance@wwu.edu or (360) 650-2146. If during or after participation in this study you suffer from any adverse effects as a result of participation, please notify the researcher directing the study or the RSP.

By clicking "Yes, I agree to participate" below you are saying that you have read this form, that you have had your questions answered, that you understand the tasks involved, that you are 18 years old or older, and volunteer to take part in this research.

- Yes, I agree to participate.
- No, I do not agree.

# Appendix D: Activities-Specific Balance Confidence Scale

**Activities-Specific Balance Confidence Scale (ABC Scale)**

"This section discusses how confident you are with particular balance and mobility activities.  On a scale from 0%-100% (0% being not confident and 100% being completely confident), please tell me how confident you feel you can do the following activities without feeling unsteady, losing your balance, or falling.  If you normally use a support (like a person or a mobility device) when doing an activity, then rate your confidence when using that support.  If you do not do the activities listed, then try to imagine how confident you would feel if you had to do the described activity."

| | **No confidence** | | | | | | | | | | **Completely Confident** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. How confident are you that you can **walk around the house** without feeling unsteady, losing your balance or falling? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 2. How confident are you that you could **walk up and down the stairs inside your home** without feeling unsteady or losing your balance? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 3. How confident are you that you could **bend over and pick up a slipper from the front of a closet floor** without feeling unsteady or losing your balance? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 4. How confident are you that you could **reach for a small can off a shelf that is at eye level** without feeling unsteady or losing your balance? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 5. How confident are you that you could **stand on your tiptoes and reach for something above your head** without feeling unsteady or losing your balance? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 6. How confident are you that you could **stand on a chair and reach for something** without feeling unsteady or losing your balance? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 7. How confident are you that you will not feel unsteady or lose your balance when you are **sweeping the floor**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |

| | No confidence | | | | | | | | | | Completely Confident |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8. How confident are you that you will not feel unsteady or lose your balance when you **walk outside of the house to the car that is parked in the driveway**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 9. How confident are you that you would not feel unsteady or lose your balance when you **get into or out of the car**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 10. How confident are you that you would not feel unsteady or lose your balance when you **walk across the parking lot to the mall**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 11. How confident are you that you would not feel unsteady or lose your balance when you **walk up or down a ramp**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 12. How confident are you that you would not feel unsteady or lose your balance when you **walk in a crowded mall where people rapidly walk towards you and pass you by?** | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 13. How confident are you that you would not feel unsteady or lose your balance when **people bump into you as you walk through the mall**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 14. How confident are you that you would not feel unsteady or lose your balance when you **step onto or off of an escalator while holding onto the railing**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 15. How confident are you that you would not feel unsteady or lose your balance when you **step onto and off of an escalator while holding onto parcels such that you cannot hold onto the railing**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |
| 16. How confident are you that you will not feel unsteady or lose your balance when you **walk outside on icy sidewalks**? | 0% | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100% |

# Appendix E: Falls Efficacy Scale—International

**Falls Efficacy Scale International (FES-I)**

"Now we would like to ask some questions about how concerned you are about the possibility of falling. Please reply thinking about how you usually do the activity. If you currently don't do the activity (e.g. if someone does your shopping for you), please answer to show whether you think you would be concerned about falling IF you did the activity. For each of the following activities, please tick the box which is closest to your own opinion to show how concerned you are that you might fall if you did this activity." **Circle your answer.**

| | | Not at all concerned 1 | Somewhat concerned 2 | Fairly concerned 3 | Very concerned 4 |
|---|---|---|---|---|---|
| 1 | Cleaning the house (e.g. sweep, vacuum or dust) | 1 | 2 | 3 | 4 |
| 2 | Getting dressed or undressed | 1 | 2 | 3 | 4 |
| 3 | Preparing simple meals | 1 | 2 | 3 | 4 |
| 4 | Taking a bath or shower | 1 | 2 | 3 | 4 |
| 5 | Going to the shop | 1 | 2 | 3 | 4 |
| 6 | Getting in or out of a chair | 1 | 2 | 3 | 4 |
| 7 | Going up or down stairs | 1 | 2 | 3 | 4 |
| 8 | Walking around in the neighborhood | 1 | 2 | 3 | 4 |
| 9 | Reaching for something above your head or on the ground | 1 | 2 | 3 | 4 |
| 10 | Going to answer the telephone before it stops ringing | 1 | 2 | 3 | 4 |
| 11 | Walking on a slippery surface (e.g. wet or icy) | 1 | 2 | 3 | 4 |
| 12 | Visiting a friend or relative | 1 | 2 | 3 | 4 |
| 13 | Walking in a place with crowds | 1 | 2 | 3 | 4 |
| 14 | Walking on an uneven surface (e.g. rocky ground, poorly maintained pavement) | 1 | 2 | 3 | 4 |
| 15 | Walking up or down a slope | 1 | 2 | 3 | 4 |
| 16 | Going out to a social event (e.g. religious service, family gathering or club meeting) | 1 | 2 | 3 | 4 |