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Longitudinal Implications of Social Integration for Age and Gender Differences in Late-Life Physical Functioning

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Abstract

Social integration has documented benefits for late-life health, yet less is known about its impacts on trajectories of physical functioning. This study examines age and gender differences in the longitudinal associations between social integration and activities of daily living (ADLs) using a hierarchical linear model with three waves of survey data collected over four years from the Social Integration and Aging Study (N=400; baseline mean age=80.3). Findings indicated some interaction effects of age, gender, and/or social integration on ADL trajectories. Among those of more advanced age, women showed greater increases in ADL limitations than men, and individuals with lower social integration experienced greater increases in ADL limitations than those with higher social integration. Neither of these patterns were found among younger older adults. This study highlights benefits of longitudinal research on social integration and the need to explore practical interventions for promoting social integration particularly among the oldest older adults.

Keywords: social integration, physical functioning, activities of daily living, gender, older adults

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The benefits of various components of social integration for physical health and functioning across the lifespan, particularly in late-life, is well documented (e.g., Thoits, 2011; Umberson & Montez, 2010; Berkman et al., 2000; Stephens et al., 2014). With greater age, men and women face increasing physical limitations that may progressively impair their quality of life (Freedman et al., 2013; Holmes et al., 2009). Longitudinal studies have reported that higher levels of social participation, an aspect of social integration, are associated with greater amounts of physical activity, better mobility, and lower physical disability among older adults (Corbett et al., 2018; Buchman et al., 2009; James et al., 2011), while other studies find no such differences (Green et al., 2008; Avlund et al., 2004). Though inconclusive, such studies highlight the potential of social integration to protect against age-related physical decline. Further longitudinal research is warranted to determine whether there are indeed benefits of social integration on physical functioning in later life as well as examine factors that underpin these associations. Moreover, it is not yet clear if the role of social integration for late-life physical functioning varies over time among men and women of different ages (i.e., young-old versus old-old). In an attempt to address this, the current study examines whether age and gender differences exist in the association between social integration and trajectories of physical functioning among older adults.

Social Integration and Physical Functioning

Various aspects of social relationships, ranging from the structure or function of social network, the quality of emotional support, the extent of social engagement and participation, or the investment in social roles, each play a role in well-being across the lifespan (Berkman et al.,

2000; Antonucci, 2001). The concept of social integration incorporates multiple components of social ties to provide a more comprehensive or overarching picture of an individual's engagement in social relationships. Social integration is a complex construct and takes various forms encompassing social networks such as family, friends, and other relations as well as engagement in social activities with groups and organizations (Fuller-Iglesias & Rajbhandari, 2016). Aging research often examines specific components of social integration, such as social networks, support quality, or community engagement (e.g., Cohen, 2004). For instance, prior research has assessed: social network composition and contact frequency (e.g., Green et al., 2008), ratings of the perceived quality or functionality of support with interpersonal partners such as family and friends (e.g., Charifian & Grühn, 2019), or the level of participation in community events or organizations (e.g., Corbett et al., 2018). Each of these separately represent important dimensions of an older adults' social well-being; however, by focusing only on one of these dimensions, we miss the overall, multidimensional social integration of an older adult. The present study examines social integration comprehensively, as an umbrella concept representing the various social ties and activities with which older adults engage.

Theoretical models have linked social integration to well-being across the lifespan (Berkman et al., 2000; Antonucci et al., 2014; Thoits, 2011). Theoretically there are various mechanisms that may explain this link such as: increasing instrumental support, fostering health-promoting behaviors, promoting coping, buffering stress, and enhancing feelings of self-worth and control, among others (Berkman et al., 2000; Thoits, 2011; Uchino, 2004). In addition to attempting to explain why social integration may influence well-being, theories also highlight personal and contextual factors that can account for variation in these links. The convoy model (Antonucci, 2001) emphasizes the important role that personal characteristics, such as gender or

age, play in determining the influence of social connections, particularly in late adulthood (Fuller et al., 2020). Moreover, the convoy model highlights the importance of recognizing change over time across and within individuals (Fuller et al., 2020). The current study is guided by these theoretical frameworks in seeking to understand whether social integration predicts trajectories of physical functioning over time among older adults, and if such associations vary by gender and age.

The ways that social integration is linked to well-being likely vary depending on physical, cognitive, emotional, or functional well-being (Thoits, 2011). For example, research has shown increased social integration in later life to be associated with reduced risk of chronic disease (Crittenden et al., 2014), lower mortality (Barger, 2013; Holt-Lunstad et al., 2010), better psychological well-being (Sharifian & Grühn, 2019), better self-rated health and cardiovascular outcomes (Ertel et al., 2009), and decreased disability (Nilsson et al., 2010). While the impact on physical functioning may be less pronounced, there is evidence of implications of social integration for physical functioning (James et al., 2011; Buchman et al., 2009; Rosso et al., 2013). Moreover, social ties and social participation are associated with higher amounts of physical activity and better mobility, which can enhance physical functioning. While theoretical works and cross-sectional studies suggest that social integration may act as a potential protective factor against age-related functional decline, longitudinal studies may hold the key to determining the predictive nature of social integration.

Some longitudinal studies support the notion that social integration may be protective for older adults physical functioning and disability (Buchman et al., 2009; James et al., 2011; Kanamori et al., 2014; Unger et al., 1999), with some even finding that social integration has the potential to improve physical functioning among older adults (Corbett et al., 2018; Zunzunegui,

2005). However, in contrast, other longitudinal studies have determined that social integration did not predict older adult's functional health or disability risk over time (Green et al., 2008; Avlund et al., 2004; Seeman & Chen, 2002). These contradictory findings warrant further investigation. Guided by the convoy model, we propose that variability in personal characteristics, such as age and gender, may help explain these contradictory findings, in that it may be the case that social integration is more predictive of trajectories of physical functioning among the oldest old as opposed to the young old, or among women as opposed to men.

Age, Social Integration, and Physical Functioning

Research over the years has shown marked decline in physical functioning with increasing age, as the prevalence of having one or more functional limitation or disability increases progressively with advancing age (Crimmins et al., 2016; Holmes et al., 2009). Indicative of these declines in physical functioning, older individuals are increasingly likely to experience challenges in their ability to carry out activities of daily living (ADLs), and the prevalence of overall ADL limitations becomes progressively greater with increasing age (Freedman et al., 2013; Martin & Schoeni, 2014; Seeman et al., 2010). Limitations in activities of daily living include difficulty with basic everyday tasks that are necessary for self-care (such as dressing, bathing, or eating) as well as more complex, instrumental household management tasks (such as financial management, cleaning, or shopping). Freedman et al. (2013) reported relatively low rates of ADL limitations for middle aged men and women (aged 55-65) and the highest rates among the oldest old (those aged 85 and older). Moreover, research on trajectories of physical functioning indicates that the rate of physical decline increases with age (Liang et al., 2008). This age disparity in physical functioning is in large part accounted for by increased disease comorbidity with age (Chatterji et al., 2015; Freedman et al., 2007; Stenholm et al.,

2015), yet research on exceptional longevity suggests that age does not strictly predict increased disability and functional decline (Christensen et al., 2008; Terry et al., 2008). For instance, if older adults maintain high social integration (i.e., having more social support, higher engagement in social activities, etc.), it may help reduce risks for decline in physical functioning (Buchman et al., 2009; James et al., 2011; Kanamori et al., 2014; Unger et al., 1999) despite their older age.

While social integration appears to be beneficial for various health behaviors and outcomes including physical functioning throughout adulthood (Thoits, 2011; Umberson & Montez, 2010), such health benefits of social integration may change with age. For example, though Elliot et al. (2017) found that social integration was not associated with lower interleukin-6 (i.e., inflammatory biomarker related to morbidity) overall for their sample aged 35 to 86, their additional analyses revealed that the association was significant for those aged 75 or older, indicating a shift with advanced age. Loneliness may be indicative of a lack of social integration, and research suggests that associations between loneliness and health may involve multiple pathways (e.g., health behaviors, neurobiological mechanisms, cognitive processes), moreover the health impacts through such pathways may become more pronounced in later life though additional research on these age differences is needed (Ong et al., 2016). Specifically, for social integration and physical functioning, research on age differences also remains limited. Some longitudinal studies found no age differences among older adults in associations of social ties (e.g., Zunzunegui et al., 2005) or social activities and participation (e.g., James et al., 2011; Otsuka et al., 2018) with reduced risks of functional disability. However, the findings of Buchman et al. (2009) were more nuanced indicating that social activity was associated with a lower rate of decline in global motor function. In other words, if older adults had lower levels of social activity, their degree of functional decline increased more rapidly over time (i.e., with

age), which seems to suggest that maintaining social integration may become more important with age for reducing risks of functional decline. Thus, the implications of social integration for trajectories of physical functioning may change with age. Due to limited prior research, additional longitudinal studies are needed to investigate how age is related to the association of social integration with trajectories of physical functioning.

Gender, Social Integration, and Physical Functioning

Men and women experience different levels and types of physical limitations as they age (Holmes et al., 2009). Women are found to experience greater disability and increased physical functioning limitations than their male counterparts (Crimmins et al., 2010). For instance, more older women than men report difficulties with ADLs such as bathing, dressing, housework, and shopping (Hardy et al., 2008; Martin & Schoeni, 2014). Gender differences in physical limitations are amplified by physical and mental health, which likewise vary by gender, as women are likely to have more chronic physical (i.e., musculoskeletal, autoimmune, etc.) and mental (i.e., depression, anxiety, etc.) health conditions than their male counterparts (Bird & Rieker, 2008). Moreover, women tend to live longer than men (Crimmins et al., 2016; Leveille et al., 2000), and thus, gender differences in physical limitations over an extended period can be attributed to higher life expectancy in women as well as higher initial levels of disability among older women compared to men (Li et al., 2018). Generally speaking, older women therefore have the potential to be physically impaired or disabled for a longer amount of time than older men.

The trajectories of physical decline over time appear to be different for aging men and women (Gill et al., 2013; Liang et al., 2008; Romoren & Blekeseaune, 2003). Different patterns have emerged across studies, but general trends suggest that older women experience more prolonged trajectories of functional limitations whereas men are more likely to experience death

prior to a prolonged trajectory of functional decline (Deeg, 2005; Gill et al., 2013; Romoren & Blekeseaune, 2003). Multiple studies have found that men are more likely than women to have stable trajectories of minimal functional impairment or disability over time, sometimes, but not always, with a sharp decline before death (Rooth et al., 2016; Verbrugge et al., 2017). Women on the other hand appear to have greater variability in their trajectories of functional limitations (e.g., Lin, 2020); evidence suggests older women are more likely than older men to have both gradually declining and improving physical functioning trajectories (Rooth et al., 2016; Deeg, 2005; Liang et al., 2008) as well as stable trajectories of moderate to severe disability over time (Gill et al., 2013). When adjusting for length-of-survival, one recent study found that older women's self-reported disability levels declined at a faster rate than men (Botoseneanu et al., 2016). Taken together, these studies highlight gender differences in trajectories of physical functioning in later life. In addition, related to gender as well as age differences, Liang et al. (2008) identified greater gender gaps in physical functioning (i.e., greater functional impairment for women than men) for those at a more advanced age (e.g., age 75+) than younger individuals, and the gender gaps increased over a decade with different trajectories between genders.

Late-life social integration varies by gender, with women more socially integrated than men on average (Thomas, 2011; James et al., 2011). Despite evidence for women's greater social engagement and increased social ties, conclusions on gender differences in how social integration is related to older adults' physical functioning are not straightforward. Cross-sectional research on just men or women suggest both genders have fewer physical limitations when they are more socially integrated (e.g., Li et al., 2018; Davidson et al., 2003). However, longitudinal studies focused on comparing gender differences paint a more complex picture. Initially, studies suggested that the protective effects of social ties (i.e., social network size,

function, and quality) for physical functioning were stronger for older men than for older women (e.g., Seeman, 1996; Unger et al., 1999). Later, contradictory findings emerged suggesting that social participation and contact were more strongly associated with reduction in disability risk for women as compared to men (Avlund et al., 2004), whereas others found no gender differences at all (Buchman et al., 2009; Zunzunegui et al., 2005). More recently, James and colleagues (2011) found that the association between social activity and risk of ADL disability was stronger for men than for women. Taken together, these studies present contradictory findings, yet they also examine different cohorts and varying aspects of both social integration and physical functioning. For example, Avlund and colleagues (2004) operationally defined social participation in terms of visiting others and attending a group activity and physical functioning in terms of first onset of disability (i.e., needing help with one of 6 mobility items). In contrast, James and colleagues (2011) operationally defined social activity with a measure of six items including attending events, meetings, religious practices, visits with others, volunteer work, and trips and physical functioning with an ADL scale. Thus, these contradictory studies differ enough in their operational definitions that based on the existing literature, it is not possible to draw clear conclusions on whether the protective nature of social integration for physical functioning varies between older men and women, especially with respect to trajectories of physical functioning over time.

Objectives

The present study aims to better understand how age and gender are related to longitudinal trajectories of physical functioning and their associations with social integration. The first objective of this study is to examine the relationship between longitudinal patterns of ADLs and gender among older individuals of varying ages. The first research question asks: Do

trajectories of physical functioning (i.e., overall ADLs) differ among older men and women of varying ages? Based on the aforementioned background, we hypothesized that trajectories of ADLs would differ by age and gender in that those of more advanced age and women would experience greater increases in ADL limitations than their younger and male counterparts, respectively. Particularly, the oldest women were expected to experience the greatest ADL limitations and steepest functional decline, aligned with previous findings (Liang et al. 2008).

Our second research question concerns the longitudinal association between social integration and physical functioning. Though prior literature was inconclusive on the association (Avlund et al., 2004; Buchman et al., 2009; Green et al., 2008; James et al., 2011), the contradicting evidence may be a result of assessing only specific aspects of social integration (such as social support or social participation). Given that we employ a comprehensive measure of social integration, we anticipated that a broad assessment of social integration would best capture any potential protective effects, thus consistent with the prior longitudinal literature reporting positive implications of social integration (Buchman et al., 2009; James et al., 2011; Kanamori et al., 2014), we anticipated that social integration is associated with physical functioning overall among older adults. In the present study, we additionally addressed age and gender differences in the association between social integration and physical functioning, which is not yet well understood. This study seeks to fill the gap in the literature by specifically addressing the following question: Do the associations of social integration with trajectories of ADLs over time vary among those of different ages and between older men and women? Considering the aforementioned (limited) research findings on age differences, we hypothesized that the association of social integration with ADLs would increase with age and over time among older adults. In contrast, we addressed gender differences in an exploratory manner

without making any directional hypothesis due to the contradictory findings of the existing literature discussed earlier, while anticipating some gender differences in the association of social integration with trajectories of ADLs.

Methods

Sample and Data

For the present study, three waves of data from the Social Integration and Aging Study (Blinded for review) were used. The study was a community-based study of older adults in a small metropolitan area in the Midwest of the United States which consisted of written surveys aimed at investigating various dimensions of social integration and their associations with health and well-being among older adults. A convenience sampling method was used to recruit participants from senior-focused organizations such as senior centers, community programs, and retirement and assisted living communities. At Wave 1 (2013), 413 individuals aged 60 or older were recruited via mail (68%) and in-person (32%). The response rate was 34% for mail recruitment, and an estimated participation was 70% for in-person recruitment. After two years, at Wave 2 (2015), a follow-up survey was mailed to all original respondents, and 307 out of them returned the Wave 2 surveys. The Wave 2 response rate was 81% (when excluding 32 participants who died between waves). Participants were again invited to complete a follow-up survey by mail two years later, at Wave 3 (2017). Among the Wave 2 participants, 245 completed the Wave 3 surveys. The Wave 3 response rate was 90% (when excluding 33 who passed away between waves). Those who completed all three waves (i.e., Wave 3 participants) differed in: age ($F(2, 410) = 19.01$, $p < .001$), level of education ($F(2, 408) = 7.14$, $p < .001$), functional limitations ($F(2, 397) = 29.47$, $p < .001$), and social integration ($F(2, 386) = 14.73$, $p < .001$). Specifically, Wave 3 participants were younger, had fewer functional limitations, and

higher social integration than those who participated in only one or two surveys; Wave 3 participants also had higher education than those who participated in only the first survey (but did not differ in education from those who participated in the previous two surveys) [1]; sex did not differ among Wave 3 participants and those who participated in only the previous one or two surveys ($\chi^2 = 4.52$, df = 2, $p > .10$).

The present study analyzed data from 400 participants who responded to demographic, social integration, and functional limitations measures at one or more waves. Their overall mean age was 80.3 years, and a majority (72%) were female. Descriptive statistics are summarized in Table 1.

(Table 1 about here)

Measures

Time Variable

A variable that would indicate the wave of the survey was created and centered at Wave 1 (= 0) (i.e., Wave 2 = 1, Wave 3 = 2). One unit of this variable represented two years, which was the period of time between two consecutive waves.

Demographic Variables

In the surveys, respondents reported their age, sex, and educational level. For the present study, baseline age at Wave 1 (in years; centered at age 80) and sex (female = 0 and male = 1) were used. Educational level was coded into the number of years and then treated as a continuous variable (e.g., high school graduate = 12, college graduate = 16, graduate degree or professional degree = 17), which was centered at 12 years.

Functional Limitations

All three waves of surveys included assessment of Activities of Daily Living utilizing the

Older Americans Resources and Service scale (Fillenbaum, 2013). Respondents were asked to indicate how much assistance they need for nine activities including Instrumental ADLs (e.g., shopping, handling money) and Basic ADLs (e.g., eating, dressing). For each item, they were given answer options including 'without help' (0), 'with some help' (1), and 'someone must do this for me' (2). The overall scale for ADL limitations was created by summing the scores for the nine items. If participants did not complete all nine items but responded to five or more items (i.e., more than half of the nine items), the average score of their completed items was imputed for each of their missing items, which was added to their overall score. These imputed overall scores were 6.9% of all valid cases. Five cases with four or fewer items (i.e., less than half of the nine items) completed were dropped from the study, which represented 0.5% of all cases with at least one of the nine items completed.

Social Integration

The three waves of surveys included items for the comprehensive Social Integration in Later Life Scale (SILLS; Blinded for review). The SILLS was designed to assess four dimensions of social integration. The subscales of the four dimensions had (1) five items for frequency of interactions with social ties including family, friends, and neighbors, (2) five items for frequency of social activities (i.e., attending meetings of a group, attending a religious service, attending a community event, volunteering, going on an outing), (3) four items for satisfaction with social ties, and (4) four items for satisfaction with social activities (i.e., recreation/leisure activities, social gatherings, religious or spiritual activities, connection to their community). Responses were given on a 5-point Likert-type scale ranging from 'never' (1) to 'very frequently' (5) for the frequency items and from 'very dissatisfied' (1) to 'very satisfied' (5) for the satisfaction items. The average scores of each of the four subscales were summed to

create an overall score. The scale alphas were .73 at Wave 1, .77 at Wave 2, and .78 at Wave 3. This variable was centered at 14.5 based on the overall mean at Wave 1.

Analysis Strategy

In order to answer the research questions, a two-level hierarchical linear modeling analysis was conducted by using IBM SPSS version 27 (IBM, 2020) with maximum likelihood, which allowed all available data at any of the three waves to be included to produce less biased estimates than listwise deletion (i.e., using only data of those who completed all items of interest at all waves) and other traditional approaches to dealing with missing data (Heck et al., 2014). To examine levels and trajectories of functional limitations, the model included level-1 time-variant variables (i.e., time/wave, social integration) and level-2 time-invariant or individual-level variables (i.e., baseline age, sex, education) as predictor or covariates as well as their interaction terms.

In the model, the fixed effect of the individual-level intercept, which was allowed to vary among individuals with its random effect, would indicate the average level of functional limitations at Wave 1 with the reference conditions (i.e., baseline age 80, female, 12 years of education, SILLS = 14.5). The time slope (i.e., the effect of wave) would indicate a change rate over time in functional limitations while it was also treated as random and allowed to vary among individuals. As results from preliminary analysis with linear and quadratic components of time slopes showed that the quadratic slope was not significant, only the linear time slope was included. In addition to the main effects of the predictors and covariates, three three-way interaction terms were entered into the model consisting of: 1) wave, age, and sex (to address research question 1), 2) wave, age, and social integration (to address research question 2A), and 3) wave, sex, social integration (to address research question 2B).

In the final model, non-significant interactions were removed if they were not a part of significant three-way interactions and if removing them improved the criterion in comparing models (i.e., Akaike's information criterion). As seen in Table 2, the hierarchical linear model with all three three-way interactions ('Full Interaction Model') indicated that the interaction of wave, sex, and social integration was not significant. After removing this three-way interaction, the lower two-way interaction of sex and social interaction remained non-significant, which was thus also then removed from the final model (see the Final Model in Table 2). Although the main effect of education was not significant, removing it would result in having a larger (i.e., worse) value of Akaike's information criterion, so, education was kept in the final model.

Using estimates for main effects and interactions in the final model, trajectories of functional limitations were depicted for those with different conditions (i.e., age, sex, social integration) for further investigations of the interactions. Post-hoc analyses were conducted using alternative hierarchical linear models that contained re-centered variables of interest (as well as all other variables included in the final model) so that the effects of covariates or predictors could be examined with the specific value or condition used in re-centering the variables (e.g., Wave 3, age 75 or 85) (Hoffman, 2015).

(Table 2 about here)

Results

Results for the final model are shown in Table 2. The main effect of wave was significant and positive (0.748, $p < .001$), which indicates that the slope or trajectory of functional limitations increased over time. In addition, the main effect of age was significant (0.173, $p < .001$), which shows that older age predicted greater levels of functional limitations. The effect of social integration was also significant (-0.202, $p < .001$), indicating that reporting

higher social integration predicted fewer functional limitations. There were no significant main effects of sex nor education, which suggests that neither sex nor education predicted levels of functional limitations. The significant random effects of intercept (6.735, $p < .001$) and wave (0.937, $p < .001$) indicated that the initial levels and slopes/trajectories over time of functional limitations varied among individuals. In addition, the two significant three-way interactions of: a) wave with age and sex and b) wave with age and social integration indicated that there were systematically varying effects on the trajectories depending on combinations of age, sex, and levels of social integration as follows.

Interaction of Wave, Age, and Sex (for Research Question 1)

The effect of the three-way interaction of wave, age, and sex is plotted in Figure 1 depicting the predicted trajectories for hypothetical men and women of two specific ages, 75 and 85 (at Wave 1), with the reference conditions (i.e., the centered values) of education and social integration based on the estimates of effects in the final model (Hoffman, 2015).

(Figure 1 about here)

As shown in Figure 1, while trajectories were similar between the younger men and women (aged 75 at Wave 1), the trajectories appeared to differ between older men and women (aged 85 at Wave 1). This gender difference for those aged 85 was found in post-hoc analyses with two alternative hierarchical linear models using the age variable centered at age 85 while either using the original wave variable centered at Wave 1 or re-centering it at Wave 3. These results indicated that for those aged 85 at Wave 1, the main effect of sex was marginal (-0.614, $p = .079$) at Wave 1 but became greater and significant at Wave 3 (-1.535, $p < .001$) with the time variable centered at Wave 3 (treated as fixed as the model with its random effect did not converge; detailed results available upon request). In addition, the two-way interaction of wave

and sex was significant for those aged 85 at Wave 1 (-.434, $p < .05$). These results indicate that for the older (initially aged 85) individuals, the gender difference of men having lower functional limitations than women became more pronounced over time as women's functional limitations increased more rapidly than men. This is contrasted with no significant effect of sex nor two-way interaction of wave and sex for those originally aged 75 over the same period of time.

Interaction of Wave, Age, and Social Integration (for Research Question 2A)

The effect of the significant three-way interaction of wave, age, and social integration is plotted in Figure 2. This figure depicts the predicted trajectories for those aged 75 and 85 (at Wave 1) having two specific levels of social integration (i.e., approximately one standard deviation below and above the centered value of SILLS) based on the estimates of effects in the final model.

(Figure 2 about here)

As seen in Figure 2, while functional limitations appeared greater for both those aged 75 and 85 with low social integration as compared to their counterparts with high social integration at Wave 1, the effect of social integration (i.e., difference between those with low and high social integration) appeared to increase more substantially over time for older individuals (aged 85 at Wave 1). This difference was indicated in the results from two post-hoc hierarchical linear models that contained the age variable re-centered at either 75 or 85 as well as the other variables included in the final model, which indicated that the two-way interaction of wave and social integration was significant only for those aged 85 (-0.184, $p < .001$; detailed results available upon request), not for those aged 75. Thus, these results indicate that social integration moderated the association between age and trajectory of functional limitations; social integration appeared to have stronger effects over time for older individuals.

Interaction of Wave, Sex, and Social Integration (for Research Question 2B)

The three-way interaction of wave, sex, and social interaction was not significant, which indicated that social integration did not moderate the association between sex and trajectory of functional limitations. In other words, the effect of social integration on trajectories of functional limitations did not differ between sexes.

Discussion

Using a longitudinal design with a relatively old sample, the present study examined potential age and gender differences in the trajectories of ADL limitations and the association between social integration and those ADL trajectories among older adults. The present study makes a unique contribution to furthering the literature on the potential health benefits of social integration by highlighting the nuance of associations between social integration and trajectories of physical functioning for older adults as discussed below.

While prior research has denoted changes in physical functioning among older adults over time, the current findings additionally identified gender and age differences in the trajectories of physical limitations among a late-life sample. As hypothesized, current findings indicated age differences in physical limitations. For example, when comparing those aged 75 (i.e., young-old) and aged 85 (i.e., old-old) at baseline, as shown in Figure 1, there was a clear distinction with old-old individuals reporting more ADL limitations as well as greater increases in their average level of ADL limitations over four years as compared to young-old individuals. In contrast to prior research (e.g., Crimmins et al., 2010) and our expectations, physical limitations did not vary by gender on average (at age 80); however, there were gender differences once age was taken into account. Specifically, while the trajectories of ADL limitations appeared similar for men and women at younger ages (i.e., young-old), the ADL

limitations of old-old women increased more rapidly over four years than their male counterparts. In contrast to previous findings documenting gender differences in levels of physical functioning (Holmes et al., 2009), which may be greater for older cohorts than younger individuals (Liang et al., 2008), the present findings are unique in showing increasing gender gaps in the trajectories of functional limitations over time for old-old individuals. Such gender gaps in increasing functional limitations may be related to older women's greater risk of physical disadvantages such as losses of muscle and bone (i.e., sarcopenia and osteoporosis) that tend to increase with age, as compared to older men (Tarantino et al., 2013), but the mechanisms of gender gaps at the oldest ages warrants further investigation.

A second contribution of this study was examining the varying implications of social integration for physical functioning among older men and women. The present findings show that social integration was associated with levels and trajectories of late-life physical functioning. Our hypotheses were partially supported in that age differences in the association between social integration and ADLs increased over time; however, anticipated gender differences were not found. Specifically, as seen in Figure 2, for old-old individuals, unlike their young-old counterparts, disparities in physical functioning appeared to increase over time between those who were more and less socially integrated. Essentially, among old-old adults, those reporting better social integration had trajectories of physical functioning (i.e., rates of functional decline) more similar to their young-old counterparts; whereas, those old-old individuals reporting poorer social integration had steeper increases in their trajectories of ADL limitations indicating more rapid declines in physical functioning over time. These findings suggest that social integration may become even more important with age for maintaining late-life functional health. Social ties and engagement are associated with better mental and physical/physiological health and health

behaviors (e.g., exercising, not smoking) (Berkman et al., 2000; Corbett et al., 2018; Thoits, 2011), which are all factors that could help aging adults reduce or delay functional decline. In other words, social integration may play a key role for promoting successful aging (Rowe & Kahn, 1997) by reducing risks of disability and helping maintain high functioning as well as promoting engagement with life. The unique conclusion of these findings is that the positive implications of social integration may increase particularly for the old-old who have greater risks of functional decline.

In contrast, no gender differences in the association of social integration with ADLs were found, suggesting that social integration may be similarly beneficial for the functional health of older men and women. Despite the apparent similarity, it is still possible that different issues may need to be considered for men and women. Given the present findings suggest that women at more advanced ages face greater risk of functional decline as compared to men and that the positive implications of social integration for physical functioning may increase with age regardless of gender, staying socially active may be especially important for old-old women to maintain their functional health. On the other hand, despite not experiencing the steeper physical functioning decline of older women, older men may still be particularly vulnerable in terms of morbidity and mortality due to their tendency to have smaller social networks and be less socially engaged than older women (Antonucci et al., 2014; McLaughlin et al., 2010; Thomas, 2011). It is thus likely increasingly important for men to maintain high social integration during their later lives. In sum, social integration seems to be a key element for promoting functional health as well as other aspects of well-being for both older men and women while different approaches to helping them maintain social integration may be required considering their potentially distinct needs.

Future Research

The current study has some strengths as well as limitations that highlight directions for future research. A key strength of the present study is the use of multiple time points of measures, which allowed longitudinal investigations on trajectories of functional limitations. Our findings suggest that by addressing questions of change over time using multiple waves, more nuanced patterns of physical functioning emerge by gender and age. Moreover, this study also provided some evidence for possible changes with age in the association of social integration with functional health, which has not been demonstrated in previous research. While the health benefits of social integration have been well documented, the focus of the present study on trajectories of physical functioning and age difference is unique and makes an important contribution to the existing literature. Future research should continue to employ the use of longitudinal designs to answer similar questions. In particular, while this study follows participants over four years, studies over even long time periods would help provide a fuller picture of the protective nature of social integration for functional health.

Another strength of the current study is the use of an older sample (aged 80 at baseline on average). Many prior studies examined differences in physical functioning between midlife and older adulthood; by using an older sample including young-old and old-old adults, the current study focused on identifying age patterns within older adulthood. While the advanced age of this sample allowed for the examination of unique age differences in late-life, the sample was a convenience sample and was somewhat lacking in gender diversity, as is common amongst studies of older adults. Given that a majority of the participants of this study were female, a future research direction would be to examine issues of gender, physical functioning and social integration within a more gender-balanced sample. In addition, a limitation of the current study

was that the participants were predominantly White (98%). This reflected the population in the specific geographic area to some extent, but it was not representative for those in more racially diverse areas as well as the national population of the United States. Thus, the generalizability of the present findings is limited and may not be applicable to people with various racial/ethnic backgrounds. Future research should replicate these findings using more diverse and representative samples of the general older population.

Finally, a strength of this study was the use of a multidimensional measure of social integration which included both satisfaction with and frequency of social support and engagement. The benefit of using such a multidimensional measure is that it provides a more holistic picture of social integration on a broad level. On the other hand, there are benefits in examining the various specific components of social integration in depth, so a future direction for this line of research is to determine whether specific aspects of social integration (e.g., social participation) plays a larger role in protecting against decline in physical functioning in late-life. Moreover, future research should examine the potential mechanisms of how various aspects of social integration can alter trajectories of functional health particularly for old-old individuals.

Practical Implications

While further investigations are warranted, the present findings can inform practice. The findings suggest that aging adults have higher risks for having greater functional limitations as they became older, and women at more advanced ages have greater risks for functional decline over time. These findings also highlight that enhancing social integration should be considered especially for old-old individuals as a potential avenue to reducing such functional decline with age. While the potential benefits of social integration for functional health may be similar for both genders, interventions to promote social integration and functional health may need to be

tailored to older women and men. For example, for older women, it could be beneficial to integrate strength training (Correa et al., 2012) into existing group social settings as an intervention to promote both social integration and physical functioning. For older men, while such physical training in a group may also be valuable, organizing social gatherings targeting older men's specific hobbies and interests may better help them stay socially connected and bolster their social integration, given their tendency to be less socially integrated than older women. These potential applied approaches to enhancing social integration and functional health should be examined in future research.

Conclusions

The present study aimed to investigate age and gender differences in the trajectories of late-life functional limitations and the association of social integration with those trajectories. In addition to providing additional evidence for greater functional decline particularly for old-old women as compared to men, the findings suggest that the link between social integration and functional health increasingly strengthens over time for old-old adults as compared to their younger counterparts. The present findings suggest future directions of research and highlights the potential benefits of enhancing social integration for older men and women to maintain their functional health.

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Footnote

[1] Table S1 in our online supplemental material shows comparisons among participants who participated in only one wave, two waves, and all three waves of the Social Integration and Aging Study.

Table 1

Descriptive Statistics for Respondents Included in the Present Study

	Wave 1	Wave 2	Wave 3
Number of Respondents (Number of Women)	400 (289)	303 (223)	244 (183)

Variable/Measure		Mean (SD) [Range of Scores]		
		Wave 1	Wave 2	Wave 3
Age (in Years)	Women	80.2 (8.2) [61-98]	81.3 (7.9) [62-100]	82.2 (7.4) [64-102]
	Men	80.4 (8.5) [60-94]	81.9 (8.6) [61-96]	82.5 (8.8) [63-96]
	Overall	80.3 (8.3) [60-98]	81.5 (8.1) [61-100]	82.3 (7.8) [63-102]
Education (in Years)	Women	13.0 (2.0) [6-17]	13.1 (2.1) [6-17]	13.3 (2.1) [6-17]
	Men	12.8 (3.4) [0-17]	13.4 (2.6) [6-17]	13.3 (2.7) [6-17]
	Overall	13.0 (2.5) [0-17]	13.2 (2.2) [6-17]	13.3 (2.2) [6-17]
Social Integration (SILLS)	Women	14.8 (2.0) [7.2-19.5]	15.2 (2.1) [7.2-20.0]	15.1 (2.0) [8.5-19.4]
	Men	14.0 (2.3) [5.4-18.4]	14.4 (2.5) [9.0-20.0]	14.7 (2.3) [8.2-19.0]
	Overall	14.6 (2.1) [5.4-19.5]	15.0 (2.2) [7.2-20.0]	15.0 (2.1) [8.2-19.4]
Functional (ADL) Limitations	Women	2.1 (3.0) [0-16]	2.2 (3.4) [0-18]	2.6 (3.6) [0-18]
	Men	2.1 (2.9) [0-12]	2.2 (3.5) [0-17]	1.9 (2.9) [0-12]
	Overall	2.1 (3.0) [0-16]	2.2 (3.4) [0-18]	2.4 (3.4) [0-18]

Note. “Overall” refers to the entire sample including all female and male respondents. Higher scores of social integration (SILLS) and functional (ADL) limitations indicate being more socially integrated and having greater limitations in ADLs, respectively. For education, Table S2 in our online supplemental material shows the frequency of each educational level.

Table 2

Estimates of Effects of Two-Level Hierarchical Linear Models for Functional Limitations: Full Interaction Model (with All Three Three-Way Interactions) and Final Model

Parameter/predictor	Full interaction model	Final model
	Unstandardized coefficient (standard error)	Unstandardized coefficient (standard error)
Fixed effect:		
Intercept	2.126 (0.169)***	2.145 (0.169)***
Wave	0.738 (0.086)***	0.748 (0.086)***
Age at Wave 0 (centered at 80)	0.174 (0.020)***	0.173 (0.020)***
Sex (Female = 0, Male = 1)	-0.201 (0.306)	-0.168 (0.306)
Education (centered at 12 years)	0.029 (0.056)	0.020 (0.055)
Social integration (SI; centered at 14.5)	-0.167 (0.061)**	-0.202 (0.052)***
Wave X Age	0.057 (0.011)***	0.056 (0.011)***
Wave X Sex	-0.183 (0.164)	-0.201 (0.164)
Wave X SI	-0.098 (0.043)*	-0.115 (0.036)**
Age X Sex	-0.087 (0.037)*	-0.089 (0.037)*
Age X SI	-0.004 (0.006)	-0.004 (0.006)
Sex X SI	-0.118 (0.111)	-
Wave X Age X Sex	-0.048 (0.020)*	-0.047 (0.020)*
Wave X Age X SI	-0.014 (0.005)**	-0.014 (0.005)**
Wave X Sex X SI	-0.054 (0.075)	-
Random effect:		
Intercept	6.646 (0.634)***	6.735 (0.638)***
Wave	0.876 (0.279)**	0.937 (0.282)***
Akaike's Information Criterion	4,173.8	4,172.9

Note. *** $p < .001$, ** $p < .01$, * $p < .05$; level-1 covariance structure: diagonal