Relationship of Social Connectedness with Decreasing Physical Activity during the COVID-19 Pandemic among Older Women Participating in the Women's Health Initiative Study

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Abstract:

BACKGROUND. Aging is generally accompanied by decreasing physical activity, which is associated with a decline in many health parameters, leading to recommendations for older adults to increase or at least maintain physical activity (PA).

METHODS. We determined relationships between social connectedness and decreasing or increasing PA levels during the COVID-19 pandemic among 41,443 participants of the Women's Health Initiative Extension Study. Outcomes of logistic regression models were decreasing PA activity (reference: maintaining or increasing) and increasing PA activity (reference: maintaining or decreasing). The main predictor was social connectedness as a combined variable: not living alone (reference: living alone) and communicating with others outside the home more than once/week (reference: once/week or less). We adjusted for age, race, ethnicity, body mass index, physical function level, and education.

RESULTS. Compared with participants who were not socially connected, socially connected participants had lower odds of decreasing PA (adjusted odds ratio 0.91, 95% confidence interval 0.87-0.95). Odds of increasing PA (vs. decreasing or maintaining PA) were not significantly different among socially connected and not socially connected participants. Associations between social connectedness and decreasing PA did not significantly differ by age (<85 vs. ≥85 years), race/ethnicity (non-Hispanic White vs. other races/ethnicity), education (college vs. <college), use of technology to stay in touch with others, or RAND physical function score (≤75 vs. >75).

CONCLUSIONS. Social connectedness was associated with lower odds of decreasing PA among older women during the pandemic. These findings could inform the development of future interventions to help older women avoid decreasing PA..

Key words: physical activity, social isolation, COVID-19. social connectedness

Introduction

Well-documented benefits of physical activity include reduced risk of heart disease, hypertension, stroke, several cancers, including breast and colorectal cancer, diabetes, falls, and premature death, as well as improved sleep, balance, and joint mobility.(1-4) Given these benefits, and recognizing the aging of the U.S. population (5, 6), it is particularly important to ensure adequate physical activity among older persons. Concerns about a decrease in PA levels during the coronavirus disease 2019 (COVID-19) pandemic (7, 8) are of major public health importance, considering that the majority of U.S. adults were not obtaining recommended levels of physical activity (PA) even before the pandemic, with fewer than 20% of women aged 65 years and older engaging in sufficient physical activity(1, 2).

The pandemic also posed challenges to maintaining social connectedness (e.g. social isolation, network size, social integration, social support), which could also adversely influence health outcomes; social isolation is associated with increased risk of death.(9) Also, among women aged between 65 and 99, social isolation and loneliness have each been independently associated with higher risk of cardiovascular disease.(10) Findings from an online survey conducted in April 2020 of over 1000 North American adults aged 50 and over suggested that even light physical activity during the COVID-19 pandemic may have alleviated some of the negative mental health impacts that older adults were experiencing while isolated and adhering to social distancing guidelines.(11) A Scottish survey (mean participant age 32 years) similarly found that less PA was associated with greater negative mood.(12) How social connectedness influences PA levels public health crises that mandate social distancing, such as the COVID-19 pandemic, is important to understand. While lack of social support during the COVID-19 was reported as a reason for not doing PA among adults in Denmark.(13), and staying in touch with family and friends and staying active were each rated as top priorities in the midst of the COVID-19 pandemic in a subset of older

women assigned to a physical activity intervention in a randomized controlled trial(14, 15), one U.S. study found no association of social support with PA during the pandemic.(16) To our knowledge, no published studies have ascertained whether social connectedness predicts greater likelihood of maintaining or increasing PA during the COVID-19 pandemic among older women in the U.S..

To examine this question, we adapted a conceptual model (**Figure 1**) from the National Academies of Sciences, Engineering, and Medicine 2020 report on Social Isolation and Loneliness in Older Adults.(17) Both quantity and quality of social connections influence physical activity. For this analysis, we were interested in the impact of social connections on physical activity. Based on previous studies, age, race/ethnicity (as a proxy for structure inequities) and socioeconomic status may influence the quality and quantity of an individual's social connections. These factors have also been associated with physical activity, therefore we considered these factors as confounders and adjusted for them in our analyses.. We considered the potential moderating effects of age, race/ethnicity, and physical function. The goal of this study was to determine the relationships between social connectedness (expressed as number of persons living in the household and the frequency of communication with others living outside the home) and decreasing PA levels or increasing PA among older women during the COVID-19 pandemic. The well-characterized cohort of older women residing across the U.S. (aged 71-104 years) participating in the Women's Health Initiative Extension study provided the opportunity to explore the hypothesis that social connectedness during the pandemic (defined as not living alone and having more than one communications per week with others living outside the household) would be associated with lower odds of decreasing PA level but would not be significantly associated with increasing PA level during the COVID-19 pandemic.

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Methods

Women's Health Initiative Study Design

Between 1993 and 1998, 161,808 postmenopausal women aged 50- to 79 years were enrolled in the Women's Health Initiative (WHI) at 40 clinical sites. The WHI consisted of the randomized clinical trials, which tested three interventions (menopausal hormone therapy, calcium plus vitamin D supplementation, and/or low-fat dietary pattern intervention), and the WHI Observational Study, which was designed to determine important causes of morbidity and mortality among postmenopausal women.(18) Women with less than three years of predicted survival or who planned to move within three years were excluded from participating, with additional exclusions for each clinical trial. After the clinical trial and observational study phase was completed (1993-2005), all active study participants were invited to continue participating for five years at their respective clinical centers (2005-2010), after which those who were still actively participating were invited to continue ongoing follow-up in the WHI Extension Study (2010-present). Each participant provided written informed consent to participate. The WHI Extension Study includes a substudy, the Women's Health Initiative Strong and Healthy (WHISH) trial, which is testing whether increasing physical activity will reduce heart disease and stroke in older women. Institutional review board approval was obtained by the institutions affiliated with four WHI regional centers and/or the WHI Coordinating Center at the Fred Hutchinson Cancer Research Center, which assumed the role of IRB of record for each participant.

In 2020, all participants who were alive and had consented to be contacted by WHI (n = 64,350) were invited to complete the WHI COVID-19 survey which included items about self-rated well-being, medical history (high blood pressure, diabetes, cancer, autoimmune disease), change in living arrangement, number of people living in the household, access to

visitors, restriction of exit and entry to home, exposure to persons suspected of being COVID-19 infected, death of family or close friends due to COVID-19, COVID-related symptoms, COVID-19 testing (frequency, nasal swab, throat swab, saliva test, blood test, test results), hospital stays or treatments for COVID-19, access to medication and health care utilization during the pandemic, degree of concern regarding the pandemic, type and frequency of communication with others outside the home, the use of technology to stay in touch with others, alcohol use, smoking, and physical activity. The COVID-19 survey included the items from the Perceived Stress Scale and the Patient-Reported Outcomes Measurement Information System Emotional Distress-Anxiety Short Form 4 (PROMIS) scale (https://www.healthmeasures.net/explore-measurement-systems/promis/intro-to-promis/list-of-adult-measures). Also, the questionnaire include an item asking "Has anyone in your family or a close friend died from COVID-19?" Response choices were "no" and "yes".

Of the 64,350 participants eligible to receive the COVID-19 survey, 49,695 (77.2%) participants completed the survey (**Figure 2**). We excluded data from participants who reported ever having had a positive COVID test (n = 311), those who did not provided data regarding change in physical activity during vs. before the pandemic (main outcome) or social connectedness (main predictor)(n = 6,651), and women for whom information regarding covariates were missing (1,290), resulting in an analytic sample of 41,443 participants.

Assessment of Physical Activity before versus during the COVID-19 Pandemic

On the COVID-19 questionnaire, participants were asked, "Over the past month, how would you describe your level of physical activity or exercise compared to your average physical activity level before the COVID-19 pandemic began?" Response choices included:

"much less", "somewhat less", "about the same", "somewhat more", and "much more". We defined maintaining PA as "about the same". For the statistical analyses, we created two binary (yes/no) outcome variables. The first variable was decreased physical activity ("much less" or "somewhat less" vs. "about the same", "somewhat more", or "much more"). The second variable was increased physical activity ("somewhat more" or "much more" vs. "much less", somewhat less", or "about the same").

Assessment of Social Connectedness

Regarding living alone, participants were asked to report the number of participants living in the household: "Including yourself, how many people living in the same household with you?" Response choices were: "1", "2", ""3, "4", "5 or more", and not applicable. For statistical analyses, we collapsed the categories to a binary variable of not living alone (1, 2, 3, 4, or 5 or more living in the same household with you) or living alone.

Regarding communication with others outside the home, participants were asked, "How often do you communicate with others who live outside your home?" The responses choices were: "every day","several X/week", "1-2 X/week", "once/week", or "rarely/never". For statistical analyses, we collapsed the categories into a binary (yes/no) variable: more than once per week ("once/week", "1-2X/week", "several X/week", or "every day") vs. once per week or less ("rarely/never", "once/week"). In addition, participants were asked "compared to the months before the outbreak began, would you say that this is…: "more often than before", "about the same as before", of "less often than before".

Based on two binary variables described above (living alone and communication with others outside the home), we defined social connectedness as a combined variable: not living alone and communicating with others more than once per week.

Other Covariates

At baseline, we used a self-assessment questionnaire for information regarding age, race, ethnicity, smoking, and highest education attained. On annual questionnaires, as well as on the COVID-19 survey, participants updated their medical history, including information regarding cardiovascular disease, peripheral artery disease, cancer, diabetes, and hypertension.

From annual questionnaires, we accessed information regarding physical function and body mass index (BMI). For each participant, we used data from the most recently-collected survey data (within the last two years) prior to the COVID-19 survey. Physical function was assessed using the RAND 36-item health survey physical functioning construct (range 0-100, higher score indicates more favorable health state).(19-21) Physical function score was categorized as <65, 65-75, 76-89, or ≥ 90. Body weight was self-reported by participants on questionnaires administered in 2018; if the 2018 information regarding body weight was missing, information from the 2013-2014 questionnaire was used. At the baseline WHI visit, height of participants was measured by trained research staff. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. A subset of participants (n = 26,847 participating in the WHISH trial), received the CHAMPS physical activity questionnaire, including information about hours per week of physical activity prior to the pandemic (prior to 3/13/2020).(22)

Statistical Analysis

We used logistic regression to determine associations between social connectedness (primary predictor) and decreasing physical activity (reference not decreasing physical activity during vs. before the COVID-19 pandemic (primary outcome). The secondary pre-

specified outcome, examined in a separate logistic regression model, was increasing physical activity (reference: not increasing) during vs. before the COVID-19 pandemic.

We adjusted the logistic regression models for potential moderators (age and education) as well as potential confounders selected *a priori:* BMI and physical function level prior to COVID-19 pandemic, race, and ethnicity. All models were adjusted for Women's Health Initiative Study component (clinical trial, observational study) and Women's Health Initiative Strong and Health Trial intervention assignment (intervention, control, not randomized). In the subset of participants who provided information regarding hours per week of physical activity prior to the pandemic (n = 26,847), we performed a sensitivity analysis in which we repeated the main analysis described above before and after adjustment for tertile of hours per week of physical activity prior to the pandemic. In another sensitivity analysis, we repeated the logistic regression models using maintained physical activity as the reference group. Specifically, we compared decreased (vs. maintained physical activity), and increased (vs. maintained) physical activity.

To test the hypothesis that associations between social connectedness and PA during (versus before) the COVID-19 pandemic differed based on characteristics selected *a priori*, we used statistical interaction terms (social connectedness * characteristic). In this way, we tested for effect modification by age (<85 vs. ≥85 years), education (no ≤high school vs. ≥ college), race and ethnicity (Non-Hispanic White vs. all other race and ethnicities), using technology to stay in touch with others (yes vs. no), physical function score (RAND 36-item health survey physical functioning score ≤75 vs. >75), and change in the frequency of communication with others outside the household during (compared with before) the pandemic.

Results

Characteristics of the Study Participants

Sociodemographic and clinical characteristics of the study participants are presented in **Table 1**. Mean (SD) participant age was 83.2 (5.4) years; mean (SD) BMI was 26.1 (5.2). Of the total group of 41,443 women, 15,679 women (38%) were aged 85 years and older. The majority of participants reported being White (n = 37,469, 90%) and non-Hispanic (40,215, 97%) with 465 participants identifying with more than one racial group. Forty-seven percent of participants reported living alone and 7% of participants reported communicating with others outside the home once per week or less.

Of the 41,443 participants, 20,092 participants (48%) were socially connected (reported communicating with others outside the household more than once per week and were not living alone); 21,351 (52%) were not socially connected.

Compared with women who were not socially connected, characteristics of those who were socially connected were similar. Socially connected women were more likely to have a high RAND physical function score (29% vs. 24% had score ≥90) and rate their well-being as excellent (53% vs. 48%); they were less likely to stay in touch with others by speaking in person (37% vs. 42%).

Characteristics of participants by level of physical activity during vs. before COVID-19 are provided in **Supplemental Table 1** (by two PA categories: maintained or increased vs. decreased PA) and **Supplemental Table 2** (by three PA categories: maintained, decreased, increased). Of the 41,443 participants, 22,547 (54%) reported that their PA during the COVID-19 was less than before the pandemic; 15,332 (37%) reported that their PA during the pandemic was the same as before the pandemic, and 3,564 (9%) reported PA during the

pandemic being more than before the pandemic. Women who reported decreasing PA were less likely to have high physical function scores, less likely to report excellent/very good well-being, and more likely to report being very concerned about the COVID-19 pandemic.

Associations between Frequency of Communication with People outside the Household and PA Levels: Results of Logistic Regression Models

We present results of two sets of models for the two pre-specified outcomes: decreased PA (primary outcome) and increased PA (secondary outcome) (**Table 2**). Compared with women who were not socially connected, in unadjusted models, women who were socially connected had significantly lower odds of decreasing their PA levels during the COVID-19 pandemic (odds ratio [OR] 0.90, 95% confidence interval [CI] 0.87-0.94). These findings persisted in fully adjusted models, with an OR of 0.91 (95% CI 0.87-0.95) after adjustment for age, race, ethnicity, BMI, physical function level, education, and WHI study component arm.

There was no statistically significant difference in the odds of increasing PA between women who were not socially connected and women who were socially connected.

In a sensitivity analysis among participants who filled the CHAMPS physical activity questionnaire prior to the pandemic, results were very similar before compared to after adjustment for tertile of pre-pandemic physical activity (**Supplemental Table 3**).

In a second sensitivity analysis, which examined increased (vs. maintained) physical activity and decreased (vs. maintained) physical activity), results were very similar to those of the primary models (**Supplemental Table 4**).

Results of Interaction Tests

Associations between social connectedness and decreased PA during vs. before the COVID-19 pandemic did not significantly differ by age (85 years-old or older versus younger than 85 years-old), race and ethnicity (non-Hispanic White versus all other race and ethnicities), education (college graduate yes vs. no), physical function level prior to the pandemic (RAND physical function score ≤75 vs. >75), use of technology to stay in touch with others (women who did not use technology vs. women who did use technology, and change in frequency of communication with others outside the household during (compared with before) the COVID-19 pandemic (all interaction p values >0.05) (**Table 3**).

Discussion

In this large cohort of older women from across the U.S., women who were socially connected were significantly less likely to decrease their PA levels during the COVID-19 pandemic than women who not socially connected. These associations between social connectedness and decreasing PA were similar among women aged 85 years and over vs. <85 years-old, women who had lower vs. higher pre-pandemic physical function score, women who reported being college graduates vs. not being college graduates, and using vs. not using technology to stay in touch with others. We had hypothesized *a priori* that social connectedness would be associated with increased or maintained PA during the pandemic. Our findings were consistent with the pre-specified hypothesis.

We cannot directly compare our results with those of previous similar studies. To our knowledge, studies have not directly assessed whether the indicators of social connectedness that we examined are associated with the odds of decreasing PA in older women during the

COVID-19 pandemic in the U.S.. However, our results are generally consistent with published studies of PA during the pandemic, such as: living with smaller number of persons in the household was associated with "unhealthy lifestyle" (composite of physical activity, nutritional components, and other features) among adults in Spain,(23), that anxiety negatively influenced the intention to do physical activity among adults in Italy,(24) that living alone was significantly related to declines in PA among adults in the U.S.(25), that more social support was associated with higher moderate-vigorous PA among adolescents in the U.S. (26), that greater social media use (Facebook, Facebook Messenger, Instagram, WhatsApp, TikTok) is related to higher step count (assessed via smartphone application) among adult psychiatric outpatients in Spain,(27) greater social support was associated with PA during the pandemic among student athletes,(28) and that higher social support is associated with better self-reported health behavior among hospitalized patients in Thailand.(29) Our findings are also consistent with studies reporting that no longer meeting PA guidelines during the COVID-19 pandemic was associated with loneliness among U.S. adults (30).

However, results of one study suggested that greater social support was not significantly associated with PA during the pandemic among U.S. adults (not specific to older persons)(16) and another study performed in Denmark found that the largest decline in minutes per week of physical activity during the COVID-19 pandemic occurred among adults who lived with their parents (40% decline), and the smallest decline in physical activity occurred among persons living alone (8% decline).(13) However, neither of the latter two studies specifically focused on older women.

While the majority of results of previously-published studies are consistent with the results and hypothesis of the current study, they are not necessarily representative of the general population of older women in the U.S., because they examined participants residing

outside of the U.S. ((13, 23, 24, 27-29), focused on special populations such as adolescents or teenagers (26, 28), psychiatric outpatients (27), hospitalized patients (29), and/or did not provide results specific to older women(23-25), (13, 16, 27, 29) Finally, results of one study suggested that greater social support was associated with PA during the pandemic among student athletes (not specific to older persons).(28)

In the broader context of interventions that have been tested to increase PA among older women, The 2018 Physical Activity Guidelines Advisory Committee Scientific Report for the Secretary of U.S. Health and Human Services found that, among older adults, the effectiveness of interventions to increase physical activity were consistently positive, but that the magnitude of the effect was not easy to determine.(https://health.gov/our-work/physical-activity/current-guidelines/scientific-report) Indeed, the limited number of studies without an active control group and the diverse range of physical activity outcomes precludes the use of meta-analysis to provide a summary of intervention effectiveness. One systematic review reported that interventions had a small effect on physical activity (Cohen's d = 0.14, 95% confidence interval 0.09-0.20), with effect sizes ranging from d = -0.02 to d = 0.63.(French et al 2014 PMID 24648017) This led the Physical Activity Guidelines Advisory Committee Scientific Report to conclude that "strong evidence demonstrates that physical activity interventions that target older adults have a small but positive effect on physical activity when compared with minimal or no-treatment controls."

Our results have public health relevance. Decreasing PA during the COVID-19 pandemic has been associated with higher depression, anxiety, and stress symptoms (Australian survey (31)), and people who exercised more during the pandemic had higher psychological resilience (cross-sectional U.S. survey) (32). Among identical twins in the U.S., a decrease in PA during the pandemic was associated with higher anxiety levels. (33) If acute changes to behavior, such as decreased PA, are sustained for longer periods of time,

they could be associated with higher risk for conditions linked with low PA, such as cardiovascular disease and diabetes.

It is difficult to ascertain cause and effect in these associations. Anxiety may have caused a decrease in PA, but the decrease in PA may have caused anxiety. For example, a study of persons in Norway aged 18-81 years found that reduced physical activity during the COVID-19 lockdown was associated with higher risk of anxiety and depression.(34) The safety of PA outdoors might be influenced by where someone lives. Also, the pandemic may increase sedentary behavior (which may have its own relationships with social connectedness) along with decreases in PA. Finally, the potential dependence of using devices to communicate with others outside the household may be a surrogate for greater wealth (allowing the purchase of electronic devices).

Our study has several potential limitations. We only had information regarding hours per week of pre-pandemic PA levels in a subset of participants (26,847 of 41,443 participants). Second, we did not have information regarding the potential influence of COVID-19 mitigation strategies on the use of certain venues for PA among our study participants, which could in part explain our results. Third, we did not have information regarding social network size, social integration, loneliness, or relationship quality. Finally, we lacked recent information regarding social support and marital status, although we were able to focus on the number of people living in the household. Results of this study cannot be generalized to social connectedness and PA during non-pandemic times, as the current study was designed specifically to evaluate PA during the COVID-19 pandemic. However, our results may apply to circumstances that result from other types of public health emergencies.

Strengths of our study include the large number of participants, the detailed information regarding covariates including physical function and technology use, and the

racial/ethnic diversity of the study cohort. In addition, we use a temporally-anchored self-report of physical activity for analyses regarding the change of activity prior to and during the pandemic in relation to social connectedness. Our results are consistent regardless of whether the comparator was defined as women who maintained PA or defined as women who did not increase (or decrease) PA, i.e. when the reference was maintained or increased, or maintained or decreased, PA. This consistency further supports our hypothesis that older women who had greater social connectedness would be less likely to decrease their PA during the COVID-19 pandemic.

In conclusion, these findings provide insights into the potential importance of maintaining communication with others outside the household and not living alone in efforts to avoiding decreases in PA among older women during future local and national crisis periods, and could inform the development of future interventions designed to help older women avoid decreasing PA more generally.

Author contributions

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Drafting of the manuscript: CJC, MLS

Critical revision of the manuscript for important intellectual content: all authors

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Figure Legends:

Figure 1. Conceptual Model

Figure 2. Strengthening the Reporting of Observational Studies in Epidemiology Analytic Sample Flow Diagram

Table 1. Sociodemographic and Clinical Characteristics of the Study Population by Social Connectedness[1]

	All Participants (n=41443)		Socially connected				
			No (n=21,351)		Yes (n=20,092)		
Characteristic	**n**	**%**	**n**	**%**	**n**	**%**	**p-value[2]**
Age, mean (SD) years	83.2	(5.4)	84.1	(5.5)	82.2	(5.2)	<0.001
<80	11916	28.8	4938	23.1	6978	34.7	
80 – 84	13848	33.4	6794	31.8	7054	35.1	
≥85	15679	37.8	9619	45.1	6060	30.2	
Race							0.003
American Indian / Alaska Native	86	0.2	51	0.2	35	0.2	
Asian	938	2.3	431	2.0	507	2.5	
Native Hawaiian / Pacific Islander	34	0.1	17	0.1	17	0.1	
Black / African American	2118	5.1	1117	5.2	1001	5.0	
White	37469	90.4	19352	90.6	18117	90.2	

[1] Social connectedness defined as living with at least one other person and communicating with others outside the household at least once per week.

[2] P-value comparing characteristic by social connectedness based on t-tests for continuous variables and chi-square tests for categorical variables.

	All Participants (n=41443)		Socially connected				
			No (n=21,351)		Yes (n=20,092)		
Characteristic	**n**	**%**	**n**	**%**	**n**	**%**	**p-value[2]**
More than one race[3]	465	1.1	217	1.0	248	1.2	
Unknown / not reported	333	0.8	166	0.8	167	0.8	
Ethnicity							0.05
Hispanic / Latina	1146	2.8	150	4.5	554	2.6	
Not Hispanic / Latina	40215	97.0	3139	95.0	20760	97.2	
Unknown / not reported	82	0.2	16	0.5	37	0.2	
Education							<0.001
≤ High school /general equivalency diploma	6107	14.7	3284	15.4	2823	14.1	
School after high school	14283	34.5	7414	34.7	6869	34.2	
≥ College degree	21053	50.8	10653	49.9	10400	51.8	
Women's Health Initiative Study Component							0.08
Clinical Trial	18280	44.1	9330	43.7	8950	44.5	
Observational Study	23163	55.9	12021	56.3	11142	55.5	
Women's Health Initiative							0.09

	All Participants (n=41443)		Socially connected				
			No (n=21,351)		Yes (n=20,092)		
Characteristic	**n**	**%**	**n**	**%**	**n**	**%**	**p-value[2]**
Strong and Healthy Trial Component							
Intervention	13280	32.0	6792	31.8	6488	32.3	
Control	13777	33.2	7040	33.0	6737	33.5	
Not Randomized	14386	34.7	7519	35.2	6867	34.2	
Body Mass Index (kg/m^2), mean (SD)	26.1	(5.2)	26.1	(5.3)	26.1	(5.2)	0.36
<25	19640	47.4	10195	47.7	9445	47.0	
25 - <30	13542	32.7	6859	32.1	6683	33.3	
≥30	8261	19.9	4297	20.1	3964	19.7	
Physical function score[4], mean (SD)	65.1	(26.9)	63.4	(27.0)	66.9	(26.7)	<0.001
<65	16625	40.1	9162	42.9	7463	37.1	
65 – 75	7500	18.1	3928	18.4	3572	17.8	
76 – 89	6514	15.7	3227	15.1	3287	16.4	
≥90	10804	26.1	5034	23.6	5770	28.7	

[4] RAND 36-item health survey physical functioning construct (range 0-100). Higher score is more favorable.

Characteristic	All Participants (n=41443)		Socially connected				p-value[2]
			No (n=21,351)		Yes (n=20,092)		
	n	%	n	%	n	%	
Smoking							<0.001
Never	21925	52.9	11000	51.5	10925	54.4	
Past	19006	45.9	10045	47.0	8961	44.6	
Current	512	1.2	306	1.4	206	1.0	
Perceived Stress Scale score, mean (SD)[5]	4.7	(2.9)	4.8	(2.9)	4.6	(2.9)	<0.001
PROMIS [6]t-score, mean (SD)	50.8	(8.3)	50.8	(8.4)	50.8	(8.2)	0.75
Medical History[7]							
Cardiovascular disease	4953	12.0	2737	12.8	2216	11.0	<0.001
Myocardial infarction	1810	4.4	1019	4.8	791	3.9	<0.001
Coronary artery bypass graft/percutaneous transluminal coronary angioplasty	2626	6.3	1442	6.8	1184	5.9	<0.001

[5] Range 0-16 (four questions with responses each scored 0-4). Higher score indicates greater stress.

[6] Patient-Reported Outcomes Measurement Information System Emotional Distress-Anxiety Short Form 4

[7] Collected at study enrollment as well as throughout study follow-up period

	All Participants (n=41443)		Socially connected				
			No (n=21,351)		Yes (n=20,092)		
Characteristic	**n**	**%**	**n**	**%**	**n**	**%**	**p-value[2]**
Stroke	1966	4.7	1102	5.2	864	4.3	<0.001
Peripheral artery disease	631	1.5	362	1.7	269	1.3	0.003
Cancer	10744	25.9	5682	26.6	5062	25.2	<0.001
Treated Diabetes	8620	20.8	4483	21.0	4137	20.6	0.31
Treated Hypertension	29568	71.3	15509	72.6	14059	70.0	<0.001
Self-rated current level of well-being							<0.001
Excellent / very good	20799	50.2	10201	47.8	10598	52.7	
Good	15032	36.3	8058	37.7	6974	34.7	
Fair / poor / very poor	5345	12.9	2937	13.8	2408	12.0	
Number of people living in household							<0.001
1	19432	46.9	19432	91.0	0	0.0	
2	17567	42.4	1221	5.7	16346	81.4	
≥3	4444	10.7	698	3.3	3746	18.6	
Friend or family member who had died from COVID-19	2068	5.0	1022	4.8	1046	5.2	0.01
Concern about the COVID-19 pandemic							<0.001

Characteristic	All Participants (n=41443)		Socially connected				p-value[2]
			No (n=21,351)		Yes (n=20,092)		
	n	%	n	%	n	%	
Not at all concerned	2546	6.1	1371	6.4	1175	5.8	
Somewhat concerned	17276	41.7	8993	42.1	8283	41.2	
Very concerned	21101	50.9	10684	50.0	10417	51.8	
Frequency of communication with others outside the home							<0.001
Every day	19924	48.1	10851	50.8	9073	45.2	
Several times per week	14129	34.1	5913	27.7	8216	40.9	
1-2 times per week	4513	10.9	1710	8.0	2803	14.0	
Once per week	1629	3.9	1629	7.6	0	0.0	
Rarely or never	1248	3.0	1248	5.8	0	0.0	
Change in frequency of communication with others outside the home compared with before the COVID-19 pandemic							<0.001
More often	6384	15.4	3465	16.2	2919	14.9	
About the same	23442	56.6	11953	56.0	11489	57.2	
Less often	10995	26.5	5572	26.1	5423	27.0	
Methods of staying in touch with others							

Characteristic	All Participants (n=41443)		Socially connected				p-value[2]
			No (n=21,351)		Yes (n=20,092)		
	n	%	n	%	n	%	
Speaking in person	16435	39.7	9031	42.3	7404	36.9	<0.001
Telephone	40058	96.7	20630	96.6	19428	96.7	0.003
Technology[8]	30910	74.6	15080	70.6	15830	78.8	<0.001
Postal mail	13358	32.2	6847	32.1	6511	32.4	0.003
Level of physical activity in past month compared with prior to COVID-19 pandemic							<0.001
Much less	10524	25.4	5746	26.9	4778	23.8	
Somewhat less	12023	29.0	6127	28.7	5896	29.3	
About the same	15332	37.0	7756	36.3	7576	37.7	
Somewhat more	2830	6.8	1357	6.4	1473	7.3	
Much more	734	1.8	365	1.7	369	1.8	

[8] Video calls, email, or social media

Table 2. Decreasing (versus Maintaining or Increasing) Physical Activity and Increasing (vs. Decreasing) Physical Activity during Pandemic by Social Connectedness[9]

	Social connectedness		
	Yes (n=20092)	**No (n=21351)**	
Decreased physical activity[10], n (%)	10674 (53.1)	11873 (55.6)	
Models	*OR (95% CI)*	*OR (95% CI)*	*p-value*
Unadjusted	0.90 (0.87, 0.94)	1.00 (ref)	<0.001
Age/Ethnicity/Race-adjusted	0.91 (0.87, 0.95)	1.00 (ref)	<0.001
Multivariate adjusted[11]	0.91 (0.87, 0.95)	1.00 (ref)	<0.001
Increased physical activity[12], n (%)	1842 (9.2)	1722 (8.1)	
Models	*OR (95% CI)*	*OR (95% CI)*	*p-value*
Unadjusted	1.15 (1.07, 1.23)	1.00 (ref)	<0.001
Age/Ethnicity/Race-adjusted	1.01 (0.94, 1.08)	1.00 (ref)	0.83
Multivariate adjusted[13]	0.99 (0.93, 1.07)	1.00 (ref)	0.87

[9]Odds ratios, corresponding confidence intervals, and p-values are from a logistic regression model with physical activity outcome (yes/no) as a function of social connectedness (yes/no) defined as not living alone and having communication outside the household more than once per week. All models adjusted for Women's Health Initiative component (clinical trial, observational study) and Women's Health Initiative Strong and Healthy Trial intervention assignment (intervention, control, not randomized).

[10] Decreased (vs. maintained or increased)

[11] Increased (vs. maintained or decreased)

[13] Multivariate models are additionally adjusted for body mass index, physical function, and education.

Table 3. Decreasing Physical Activity in Pandemic by Social Connectedness, by Subgroups

Subgroup	**Total n**	**Decreased physical activity, n (%)**	**Socially connected vs. not, odds ratio (ref)**[14]	**Interaction p-value**
All participants	*41443*	*22547 (54.4%)*	*0.91 (0.87, 0.95)*	
Age, years				0.24
<85	25764	13940 (54.1%)	0.93 (0.88, 0.97)	
≥85	15679	8607 (54.9%)	0.88 (0.83, 0.94)	
Education				0.54
≤ School after high school	20390	10526 (51.6%)	0.90 (0.85, 0.95)	
College graduate	21053	12021 (57.1%)	0.92 (0.87, 0.97)	
Technology use to stay in touch				0.60

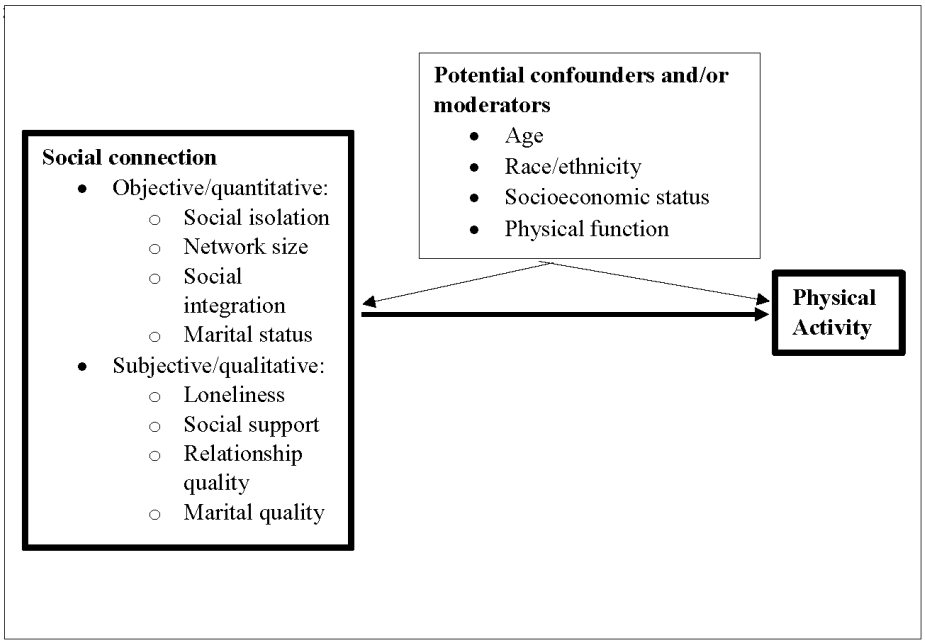
[14] Odds ratios, corresponding confidence intervals, and interaction p-values are from a logistic regression model with decreasing physical activity (yes/no) as a function of social connectedness (yes/no), the subgroup of interest, and their interaction, adjusted for WHI component (clinical trial, observational study), age, ethnicity, race, BMI, physical function, and education.

with others[15]				
Yes	30910	17254 (55.8%)	0.89 (0.85, 0.93)	
No	10412	5231 (50.2%)	0.91 (0.84. 0.99)	
Race/Ethnicity				0.55
Non-Hispanic white	36653	19679 (53.7%)	0.91 (0.87, 0.95)	
All other race/ethnicities[16]	4790	2868 (59.9%)	0.88 (0.78, 0.99)	
Physical Function score (RAND 36-item health survey physical functioning construct)				0.06
≤75	24125	13891 (57.6%)	0.88 (0.84, 0.93)	
>75	17318	8656 (50.0%)	0.95 (0.90, 1.01)	
Change in frequency of communication during (compared with before) the COVID-19 pandemic				0.19
More often / Same	29826	15101 (50.6%)	0.92 (0.88, 0.96)	
Less	10995	7125 (64.8%)	0.86 (0.80, 0.94)	

[15] Video calls, email, or social media

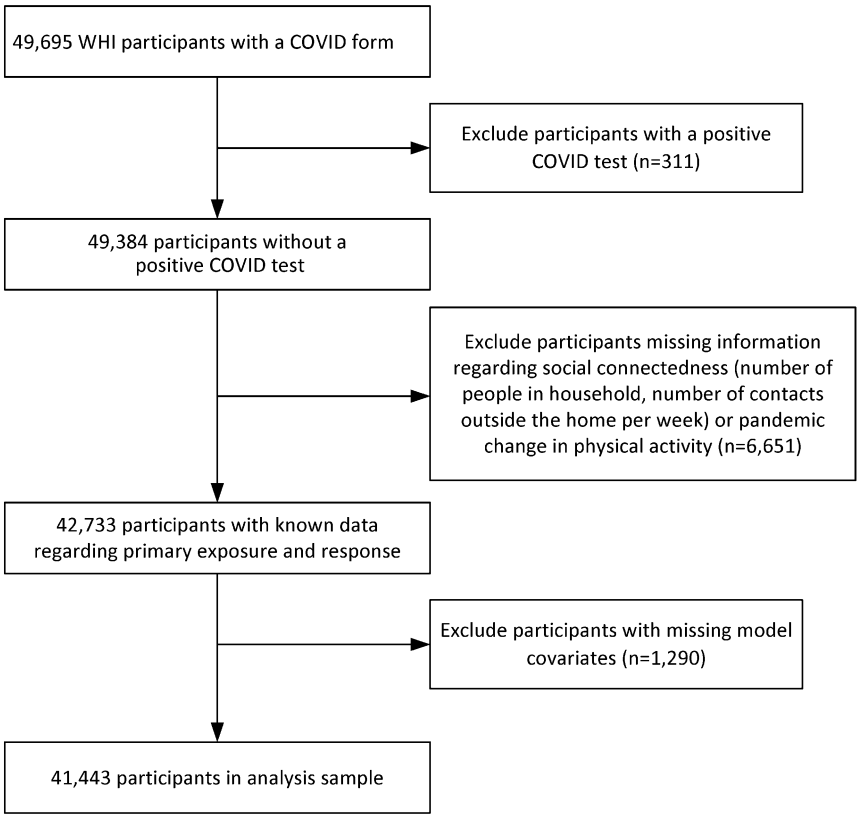
[16] Includes participants with unknown race and/or ethnicity

Figure 1. Conceptual Model[*]



[*] Modified from National Academies of Sciences, Engineering, and Medicine 2020. Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System. Washington, DC: The National Academies Press. https://doi.org/10.17226/25663

Figure 2


49,695 WHI participants with a COVID form
Exclude participants with a positive COVID test (n=311)
49,384 participants without a positive COVID test
Exclude participants missing information regarding social connectedness (number of people in household, number of contacts outside the home per week) or pandemic change in physical activity (n=6,651)
42,733 participants with known data regarding primary exposure and response
Exclude participants with missing model covariates (n=1,290)
41,443 participants in analysis sample