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The association between physical activity and social isolation in community-dwelling older adults

Lauren M. Robins ^{a,b}, Keith D. Hill^c, Caroline F. Finch ^d, Lindy Clemson^e and Terry Haines^{b,f}

^aFaculty of Medicine, Nursing and Health Sciences Department of Physiotherapy, Monash University, Melbourne, Australia; ^bAllied Health Research Unit (AHRU), Kingston Centre, Monash Health, Melbourne, Australia; ^cSchool of Physiotherapy and Exercise Science, Faculty of Health Sciences, Curtin University, Perth, Australia; ^dAustralian Centre for Research into Injury in Sport and its Prevention (ACRISP), Federation University, Ballarat, Australia; ^eAgeing, Work & Health Research Unit, Faculty of Health Sciences, The University of Sydney, Sydney, Australia; ^fFaculty of Medicine, Nursing and Health Sciences, Department of Physiotherapy, Southern Physiotherapy Clinical School, Monash University, Melbourne, Australia

ABSTRACT

Objectives: Social isolation is an increasing concern in older community-dwelling adults. There is growing need to determine effective interventions addressing social isolation. This study aimed to determine whether a relationship exists between physical activity (recreational and/or household-based) and social isolation. An examination was conducted for whether group- or home-based falls prevention exercise was associated with social isolation.

Methods: Cross-sectional analysis of telephone survey data was used to investigate relationships between physical activity, health, age, gender, living arrangements, ethnicity and participation in group- or home-based falls prevention exercise on social isolation. Univariable and multivariable ordered logistic regression analyses were conducted.

Results: Factors found to be significantly associated with reduced social isolation in multivariable analysis included living with a partner/spouse, reporting better general health, higher levels of household-based physical activity (OR = 1.03, CI = 1.01–1.05) and feeling less downhearted/depressed. Being more socially isolated was associated with symptoms of depression and a diagnosis of congestive heart failure (pseudo $R^2 = 0.104$).

Discussion: Findings suggest that household-based physical activity is related to social isolation in community-dwelling older adults. Further research is required to determine the nature of this relationship and to investigate the impact of group physical activity interventions on social isolation.

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KEYWORDS

Exercise; geriatrics; social isolation; household activity; recreational

Background

The burden of social isolation in older adults living in the community is of increasing concern to health care workers and policy-makers alike. Social isolation can be defined as 'living without companionship, having low levels of social contact, little social support, feeling separate from others, being an outsider, isolated and suffering loneliness' (Hawthorne, 2006, p. 526). Social isolation has often been described as a quantitative measure of an individual's social relationships, however, the definition of social isolation as a qualitative reflection of relationships has been demonstrated to be a more important consideration (Routasalo, Savikko, Tilvis, Strandberg, & Pitkälä, 2006; Victor, Scambler, Bond, & Bowling, 2000). Poor social relationships have been demonstrated to be more strongly associated with mortality than smoking 15 cigarettes per day or drinking more than six alcoholic beverages daily (Holt-Lunstad, Smith, & Layton, 2010). In addition to increased mortality rates, social isolation increases risk of poor mental and physical health, dementia, falls, and rehospitalisation (Cornwell & Waite, 2009; Faulkner, Cauley, Zmuda, Griffin, & Nevitt, 2003; Fratiglioni, Wang, Ericsson, Maytan, & Winblad, 2000; Mistry, Rosansky, McGuire, McDermott, & Jarvik, 2001). A review of literature concerning social isolation in British community studies, conducted in 2000, reported that approximately 10% of older adults were socially isolated with a reported range within individual communities of 2%–20% (Victor et al., 2000).

Current research reports social isolation to be experienced by 15% of older adults living in London (Iliffe et al., 2007), 16% in Australia (Hawthorne, 2008), 25% in Japan (Shimada et al., 2014) and 49% in Malaysia (Ibrahim, Abolfathi Momtaz, & Hamid, 2013). Not surprisingly, the World Health Organization lists social isolation in older adults as a major target for worldwide health policy (Wilkinson & Marmot, 2003). It is with the increased risk of poor health associated with social isolation in mind that researchers are seeking to further explore the nature and prevalence of social isolation in older adults.

A number of risk factors for social isolation in older adults are reported in the literature. These include increasing age, being widowed or single, living alone, childlessness, living in a rural location, ethnicity, poor health, comorbidities, restricted mobility, history of falls, depression, impaired memory, low social class, decreased access to transport, no telephone, death or loss of friends or family, and retirement (Barnes, Blom, Cox, & Lessof, 2006; Iliffe et al., 2007; Jang et al., 2015; Wenger & Burholt, 2004). There is contradicting evidence in relation to gender with some research finding females to be more at risk of social isolation (Barnes et al., 2006; Giuli et al., 2012; Ibrahim et al., 2013) and other studies reporting men as being at higher risk (Edelbrock et al., 2001; Iliffe et al., 2007; Jang et al., 2015). Hawthorne (2008) found that the more health conditions reported, the greater the risk of being socially isolated. Therefore, those with multiple comorbidities are at a higher risk of becoming socially isolated. One study (Steptoe, Shankar,

Demakakos, & Wardle, 2013) found that social isolation was related to illnesses such as chronic lung disease and arthritis, whereas loneliness was shown to be related to a greater range of health conditions including coronary heart disease, chronic lung disease, stroke, arthritis and clinical depression. It is possible that these chronic health conditions limit an older adults' ability to be involved in social activities outside their own home and hence reduce opportunities for social interaction. Or perhaps they were already socially isolated and, without the support and advice of friends and family, had neglected health concerns or poor health behaviour that might otherwise have been recognised and treated earlier in order to prevent the development of chronic conditions.

Various authors have reviewed research investigating interventions to address social isolation and concluded that insufficient evidence exists to support any particular intervention (Cattan, White, Bond, & Learmouth, 2005; Dickens, Richards, Greaves, & Campbell, 2011; Findlay, 2003). The approaches summarised in these reviews include health care staff support providing telephone contact, home visits, support groups, group and individual mental health counselling, also group social activity interventions and education programs on the topics of health, social support services, friendship enrichment, and computer, internet and email use. Falls prevention exercise interventions have not previously been investigated for their impact on, or relationship with, social isolation. It is possible that they may have a direct impact on the amount of social contact older adults engage in if the exercises are performed in a group environment. It is also possible that they may indirectly impact on social isolation, an effect mediated through improved physical capacity, creating greater opportunity to get out of the house and attend social activities without falling. Although no particular approach has been identified as being effective in preventing or reducing social isolation, participating in group interventions was suggested as being an important element in the likely success of an intervention (Cattan et al., 2005; Dickens et al., 2011). The recommendation that group interventions be used to target social isolation suggests social interaction may be required to improve levels of social isolation. However, the lack of evidence supporting social interventions alone means the nature of activities to be performed requires further consideration, and may impact on outcomes.

An approach that might be effective in addressing social isolation could be to engage older adults in physical activity programs, such as a group- or home-based falls prevention exercise. An association has previously been demonstrated between physical activity and the quality of life domain for 'social functioning' (Acree et al., 2006; Vagetti et al., 2014). It therefore stands to reason that increased physical activity might be related to reduced social isolation. It is unclear from existing research, whether recreational physical activity or household-based physical activity might be more closely related to social isolation. Older adults have been demonstrated to have diminishing participation in recreational physical activity, such as team and individual sports and organised exercise groups, and tend to engage in household-based activities more often (Benzinger et al., 2014; Brownson et al., 2000; Crombie et al., 2004). One could postulate that recreational physical activity would be more closely related to social isolation because of the concurrent social activity inherent to some recreational physical activities for example playing bowls or golf, however this is yet to be demonstrated. Recreational

physical activity has the potential added benefits of meeting others with shared interests, broadening social networks and improved ability to access services outside the home. These added benefits might serve to reduce the likelihood of an individual becoming socially isolated. Conversely, older adults may face increasing difficulty in maintaining their home as they age, which may lead to a sense of shame and reluctance to invite people into their homes, reducing opportunities for social interaction. Hence, lower levels of participation in household-based physical activities could also theoretically be linked to social isolation in older adults. It is important to address whether a relationship exists between social isolation and physical activity in older community-dwelling adults, and also whether recreational or household-based physical activity might be more associated. Improving participation in either recreational or household-based physical activity presents different challenges to health professionals, if there is evidence to support an association with social isolation. However, identifying which might be more relevant brings us one step closer to determining effective interventions for treating and managing social isolation in older adults.

The aim of this paper is to determine whether there is a relationship between physical activity (recreational and/or household) and social isolation in older community-dwelling adults. The study also investigates whether self-reported ill-health and comorbidity are associated with social isolation. Additionally, a potential association between participation in group- or home-based falls prevention exercise with social isolation was investigated. These findings will indicate whether physical activity programs have the potential to be used to reduce the burden of social isolation in older adults and help to identify those older adults living in the community who need to be targeted by social isolation interventions.

Methods

Design

The data to address the research question were extracted from results of a broader investigation into falls prevention in Victoria, Australia (Day et al., 2011; Lee et al., 2015; Robins et al., 2016). Two cross-sectional telephone surveys were conducted approximately one year apart, this study utilised data gathered during the 12-month follow-up. The follow-up telephone survey examined levels of and reasons for participation in falls prevention activities, along with a number of other health indicators. Social isolation data were only collected at follow-up which formed the cross-sectional design. The study was approved by the Monash University Human Research Ethics Committee.

Participants

The participants, recruited through random digit-dialling from the Victorian (Australia) 2006 residential telephone records, were older adults 70+ years, living in the community. Respondents were required to be able to speak proficient English for the telephone survey to be conducted. People with significant cognitive impairment (score of 13 or more, rated using a 6-item cognitive impairment screen) (Brooke & Bullock, 1999) were excluded. Recruitment for this project included equal numbers of people with and without pre-determined chronic medical conditions (diabetes, congestive

heart failure, pulmonary disease, renal disease, depression or anxiety). The follow-up telephone survey was conducted approximately one year later with those who consented to be contacted after the first telephone survey. No new survey respondents were recruited for the follow-up telephone surveys. The recruitment and flow of respondents for the telephone surveys have been reported previously (Lee et al., 2013).

Measurements

Telephone questionnaires were based on existing instruments previously used to examine risk of falls and perceptions towards participation in falls prevention interventions applied in hospital in-patient settings (Figueira et al., 2012; Lund, Michelet, Sandvik, Wyller, & Sveen, 2012; Thraen-Borowski, Trentham-Dietz, Edwards, Koltyn, & Colbert, 2013). The main items of interest for this paper were the Friendship Scale for social isolation (Hawthorne, 2008), the Phone-FITT for physical activity participation (Gill, Jones, Zou, & Speechley, 2008) and items from the SF-12 to measure physical capacity including whether the respondents' health limited their moderate activities and ability to climb stairs (each on a scale of 1–3, 1 = limited a lot, 2 = limited a little, 3 = not limited at all) (Ware, Kosinski, & Keller, 1996). The Friendship Scale (measure of social isolation) is short and user-friendly and measures six dimensions contributing to social isolation and social connection with scores ranging from 0–24 (0–11 = very socially isolated, 12–15 = isolated, 16–18 = some social support, 19–21 = socially connected, 22–24 = very socially connected (Hawthorne, 2008). This scale requests that respondents consider the previous four weeks and report on (1) ease of relating to other people, (2) isolation from others, (3) having someone to share feelings with, (4) ease of being able to contact others when needed, (5) feeling separate from others and (6) feeling alone and friendless. Possible response options appear on a five-point ordinal scale and include 'almost always,' 'most of the time,' 'about half the time,' 'occasionally,' and 'not at all.' The Phone-FITT allows respondents to report on both household physical activities (e.g. cooking, cleaning and tidying) along with recreational physical activities (e.g. lifting weights, playing golf, sports and gardening) participated in during an average week in the past month. Respondents are required to report whether they have engaged in each activity listed (yes/no), how many times per week and the duration (0 = 0 minutes, 1 = 1–15 minutes, 2 = 16–30 minutes, 3 = 31–60 minutes and 4 = 1 hour+). Separate household and recreational physical activity scores were derived from the frequency and duration data by adding the two across all relevant questions, as recommended by Gill et al. (2008) who demonstrated that multiplication of data leads to overestimation of activity levels. A total physical activity summary score was calculated by adding the household and recreational scores. Higher scores indicate greater levels of physical activity participation.

Demographic data tested for a possible association with social isolation included: age, gender, ethnicity (1 = born in Australia, 0 = born overseas) and diagnosis of a range of medical conditions. Additionally considered were the respondent's living arrangement (live alone, live with partner or spouse, live with son or daughter or live with other family member), whether the respondent had a fall in the past year, the Geriatric Depression Scale (GDS) (scores range from 0–30, 0–

10 is viewed as normal, 11+ is an indicator of depression) (D'Ath, Katona, Mullan, Evans, & Katona, 1994), SF-12 individual items measuring general health (scale of 1–5, 1 = excellent, 5 = poor), feeling downhearted and depressed (scale of 1–5, 1 = all of the time, 5 = none of the time), whether physical or emotional health interfered with social activities (scale of 1–5, 1 = all of the time, 5 = none of the time) (Ware et al., 1996) and whether the respondent was participating in group- or home-based falls exercise interventions.

Procedure

Participants recruited for the first telephone survey ($n = 385$) were asked at its completion whether they consented to be contacted again for a follow-up ($n = 368$ agreed). Respondents who agreed to be contacted were then telephoned one year later for a follow-up survey ($n = 245$). A date and time was arranged for a researcher to call and conduct the telephone survey and an information package was mailed to respondents prior to conducting the telephone interview. The mailed package contained the details of the telephone survey appointment and survey response options to assist participants in answering a number of the questions. Researchers and research assistants then conducted follow-up telephone surveys for those who consented to participate. Responses were typed into a database by researchers during the telephone conversation.

Statistical analysis

A number of univariate analyses were conducted to evaluate the association between the selected variables and social isolation. These particular variables were chosen from the available data based on previous research into risk factors for social isolation. Previous research has identified a number of factors associated with social isolation; these were separated into personal circumstances, health, resources and life events (for the list and references see Table 1). Many of these variables were considered for their relationship with social isolation to account for their possible effects in a multivariable analysis. All analyses were conducted using STATA software (StataCorp, 2013).

Univariate analyses were conducted using ordered logistic regression. The decision was made to treat the Friendship Scale outcome data as an ordinal variable as the data were not normally distributed and linear regression analyses of the Friendship Scale against predictor variables demonstrated heteroscedasticity. Potential data transformations to address the linear regression assumption violations were investigated, however, square and cubic transformations made little difference to this situation. Therefore, univariate ordinal logistic regression analyses were used to identify variables with a p -value < 0.25 for their association with Friendship Scale scores for inclusion in a multivariable analysis (Hosmer & Lemeshow, 2004). No changes were made to participants' individual Friendship Scale scores in order to perform ordered logistic regression analyses. The odds ratios (OR) and 95% confidence intervals, McFadden's pseudo R^2 and p -value were reported for each of the selected variables for the univariate analyses.

Backwards elimination multiple ordered logistic regression analysis was used to determine whether a relationship exists between self-reported physical activity and social isolation

Table 1. Considered risk factors for social isolation, and study timeframes for measurement of risk factors.

	Literature	Baseline survey	Follow-up survey	References
<i>Personal circumstances</i>				
Increasing age	Yes	Yes	No	Barnes et al. (2006), Edelbrock et al. (2001), Giuli et al. (2012), Ibrahim et al. (2013), Iliffe et al. (2007)
Male	Yes	Yes	No	Edelbrock et al. (2001), Iliffe et al. (2007), Jang et al. (2015)
Female	Yes	Yes	No	Barnes et al. (2006), Giuli et al. (2012), Ibrahim et al. (2013)
Widowed or single	Yes	Yes	No	Barnes et al. (2006), Edelbrock et al. (2001), Ibrahim et al. (2013), Jang et al. (2015)
Living alone	Yes	No	Yes	Barnes et al. (2006), Hawthorne (2008), Jang et al. (2015), Wenger and Burholt (2004)
Childless	Yes	No	No	Barnes et al. (2006)
Rural location	Yes	No	No	Barnes et al. (2006)
Ethnicity	Yes	Yes	No	Hawthorne (2008), Ip, Lui, and Chui (2007), Jang et al. (2015)
<i>Health</i>				
Poor health	Yes	No	Yes	Barnes et al. (2006), Iliffe et al. (2007), Jang et al. (2015), Wenger and Burholt (2004)
Chronic disease/s	Yes	Yes	Yes	Hawthorne (2008), Iliffe et al. (2007)
Restricted mobility	Yes	No	Yes	Barnes et al. (2006), Giuli et al. (2012), Iliffe et al. (2007), Jang et al. (2015), Litwin (2003), Wenger and Burholt (2004)
History of falls	Yes	No	Yes	Barnes et al. (2006)
Depression	Yes	No	Yes	Barnes et al. (2006), Cacioppo, Hawkley, and Thisted (2010), Giuli et al. (2012), Hawthorne (2008), Iliffe et al. (2007)
Impaired memory	Yes	No	No	Iliffe et al. (2007)
Low amounts of physical activity	No	No	Yes	(Robins, Jansons, & Haines, 2016)
<i>Resources</i>				
Low social class/income	Yes	No	No	Barnes et al. (2006), Broese Van Groenou and Van Tilburg (2003), Ibrahim et al. (2013), Jang et al. (2015), Litwin (2003)
Decreased access to transport	Yes	Yes	No	Barnes et al. (2006)
No telephone	Yes	No	No	Barnes et al. (2006), Wenger and Burholt (2004)
<i>Life events</i>				
Loss	Yes	No	No	Wenger and Burholt (2004)
Retirement	Yes	No	No	Barnes et al. (2006)

and to identify any associations between self-reported ill-health or comorbidity and social isolation. Backwards elimination was performed in order to reduce the predictor variables to those that were significant and accounted for nearly as much of the variance as accounted for by the total set. The variables identified by univariate analyses with p -value < 0.25 were considered for inclusion in the multivariable analysis. However, total physical activity was to be forced into a multivariable model and then compared to another multivariable model that forced the separate outcomes of household-based physical activity and recreational physical activity to be included, in order to allow for comparison of the types of physical activity. Multicollinearity was examined using the variance inflation factor (VIF), and any variables with a VIF > 10 were considered for possible exclusion from the multivariable analysis (O'Brien, 2007). Prior to conducting the multivariable analysis, the decision was made to exclude the SF-12 item assessing the influence of physical or emotional health on social activities as it was considered to measure a construct very similar to the Friendship Scale. Living alone and living with a partner/spouse were considered opposites for this study; therefore, both variables were entered into the multivariable analysis separately and assessed for the impact on the pseudo R^2 . The variable that resulted in the higher pseudo R^2 was included in the final multivariable analysis. The Phone-FITT total score includes both the recreational and household scores so the multivariable analysis was conducted separately for the Phone-FITT total score and then for the Phone-FITT household and recreational scores. The variable that resulted in the higher R^2 was included in the final multivariable analysis. A backwards stepwise elimination process was then used and variables with the highest p -value were removed from the equation one-at-a-time and the change assessed for its impact on pseudo R^2 . All non-significant variables were removed until all remaining variables had a p -value < 0.05 for

their association with Friendship Scale scores. The variables that were removed were then individually added back into the model and tested for their impact on the Akaike Information Criterion (AIC) and were excluded from the final model if AIC increased. The remaining variables were reported with their OR, standard error, 95% confidence interval (95% CI), p -value and the pseudo R^2 for the analyses.

Results

A total of 385 respondents completed the baseline telephone surveys, with 368 agreeing to be contacted for the 12-month follow-up and 245 consenting to participate in the cross-sectional follow-up surveys (105 refused to participate or could not be contacted and 18 failed the cognitive screen). Relevant demographic data for respondents who completed the follow-up telephone surveys are presented in Table 2, there were no significant differences in these variables between those who did and did not consent to participate in the follow-up. The mean age at follow-up was 77 years, 66% were female and 82% were born in Australia. Data were not available for every respondent who completed the follow-up survey for each question. The number of respondents for which data were available is reported in Table 2. The mean social isolation score at follow-up was 20; 2% ($n = 5$) were considered to be very isolated, 6% ($n = 15$) isolated, 20% ($n = 49$) had some social support, 28% ($n = 69$) were socially connected and 43% ($n = 106$) were very socially connected.

A number of variables were identified as significantly related to social isolation in the univariate analyses, however, were not considered to be very important individually due to their low R^2 (Table 2). The factors found to be protective against perceived social isolation were living with a partner, feeling less downhearted and depressed, reporting that physical or emotional health interfered less in social activities and

Table 2. Univariate analyses for relationship of individual variables with social isolation (Friendship Scale scores).

Variable	Data available (n)	Variable summary	OR (95% CI) ^a	p-Value ^b	R ²
Friendship Scale – mean (SD)	244	20 (3)			
Age (years) – mean (SD)	245	77 (6)	0.98 (0.94, 1.02)	0.34	<0.01
Gender (female) – n (%)	245	148 (60%)	0.96 (0.61, 1.51)	0.88	<0.01
Born in Australia – n (%)	226	182 (82%)	1.25 (0.70, 2.23)	0.46	<0.01
Diagnosis of:					
Congestive heart failure – n (%)	244	10 (4%)	0.19 (0.06, 0.65)	0.01*	0.01
Heart disease – n (%)	243	79 (33%)	1.23 (0.77, 1.97)	0.38	<0.01
Stroke – n (%)	245	21 (9%)	0.63 (0.28, 1.42)	0.27	<0.01
Cancer – n (%)	244	60 (25%)	0.94 (0.56, 1.57)	0.81	<0.01
Diabetes – n (%)	244	43 (18%)	0.77 (0.44, 1.37)	0.38	<0.01
Lung Disease – n (%)	245	39 (16%)	0.58 (0.31, 1.09)	0.09	<0.01
Parkinson's disease – n (%)	244	2 (1%)	1.75 (0.24, 12.89)	0.58	<0.01
At least one comorbidity [congestive heart failure, another form of heart disease, stroke, cancer, osteoporosis or osteopenia (not osteoarthritis), depression or anxiety, arthritis, diabetes, lung disease, Parkinson's disease, inner ear dysfunction affecting balance (e.g. dizziness), cataracts (other visual impairment)] – n (%)	245	229 (93%)	1.53 (0.56, 4.19)	0.40	<0.01
Faller – n (%)	244	93 (38%)	1.03 (0.66, 1.62)	0.90	<0.01
Participating in group-based falls exercise – n (%)	245	53 (22%)	1.07 (0.64, 1.80)	0.78	<0.01
Participating in home-based falls exercise – n (%)	245	57 (23%)	1.19 (0.71, 2.00)	0.51	<0.01
Geriatric Depression Scale (scale 0–30) – mean (SD)	239	2 (2)	0.61 (0.53, 0.71)	<0.001*	0.04
Living arrangement					
Live alone – n (%)	245	121 (49%)	0.30 (0.19, 0.48)	<0.001*	0.02
Live with partner/spouse – n (%)	245	105 (43%)	3.71 (2.33, 5.92)	<0.001*	0.03
Live with son/daughter – n (%)	245	18 (7%)	0.68 (0.30, 1.54)	0.36	<0.01
Live with other family member – n (%)	245	1 (0.4%)	4.14 (0.23, 74.90)	0.34	<0.01
SF-12					
General health (scale of 1–5) – mean (SD)	244	2 (0.8)	0.45 (0.34, 0.61)	<0.001*	0.03
Health limits moderate activities (scale of 1–3) – mean (SD)	244	3 (0.7)	1.01 (0.74, 1.38)	0.96	<0.01
Health limits ability to climb stairs – mean (SD)	244	2 (0.7)	1.20 (0.87, 1.66)	0.26	<0.01
Felt downhearted and depressed (scale 1–5) – mean (SD)	244	4 (0.8)	2.89 (2.11, 3.96)	<0.001*	0.04
Physical/emotional health interfered with social activities (scale 1–5) – mean (SD)	244	5 (0.8)	1.49 (1.14, 1.95)	0.003*	0.01
Phone-FITT					
Household – mean (SD)	244	36 (14)	1.04 (1.02, 1.06)	<0.001*	0.02
Recreational – mean (SD)	244	17 (11)	1.04 (1.02, 1.06)	<0.001*	0.01
Phone-FITT total score – mean (SD)	244	53 (20)	1.03 (1.02, 1.05)	<0.001*	0.03

Note: OR = odds ratio; CI = confidence interval.

*Statistical significance at p -value < 0.05.

^aBased on ordinal logistic regression for association with Friendship Scale scores (for social isolation).

^b p -Value for odds ratio (95% CI).

reporting participation in higher levels of physical activity. Factors that increased the likelihood of feeling socially isolated were living alone, having a diagnosis of congestive heart failure, reporting poorer general health and depressive symptoms (as measured by GDS).

The variables with a p -value < 0.25 included in the multivariable model, were living with a partner or spouse, Geriatric Depression Scale, the SF-12 measure reporting feeling downhearted and depressed, general health, congestive heart failure, lung disease, phone-FITT recreational, phone-FITT household (pseudo $R^2 = 0.1047$). The decision to include living with a partner or spouse instead of living alone was made due to, living with a partner or spouse resulting in a larger R^2 . The Phone-FITT recreational and household scores resulted in a larger R^2 than did the Phone-FITT total score and were included in the final model (0.1047 and 0.1033, respectively). Between home-based physical activity and recreational, only the relationship of home-based physical activity was

significantly associated with social isolation in this multivariable analysis with an odds ratio of 1.03 (CI = 1.01, 1.04, p -value = 0.002), recreational was not significant with an odds ratio of 1.00 (CI = 0.99, 1.03, p -value = 0.455). The variance inflation factors for this model ranged from 1.05 to 1.52; so none of the variables were considered to be collinear and all were included in the multivariable analysis. Following backward elimination the variables associated with being less socially isolated were living with a partner or spouse, reporting better general health, reporting higher levels of household-based physical activity participation and being less downhearted (Table 3). An increased risk of feeling socially isolated was associated with experiencing more symptoms of depression (as measured by the GDS) and having a diagnosis of congestive heart disease ($R^2 = 0.104$) (Table 3). Neither of the excluded variables (recreational physical activity and diagnosis of a lung condition) was able to be re-added to the final multivariable model based on the evaluation of AIC.

Table 3. Multivariable analysis for relationship of variables with social isolation ($n = 244$).

	OR (95% CI)	Standard error	p-Value
Felt downhearted and depressed (SF-12 item, scale 1–5)	2.38 (1.65, 3.42)	0.44	<0.001
Live with partner/spouse	2.57 (1.58, 4.18)	0.64	<0.001
Household-based physical activity (Phone-FITT)	1.03 (1.01, 1.05)	0.01	0.001
Symptoms of depression (GDS, scale 0–30)	0.78 (0.66, 0.92)	0.06	0.003
General health (SF-12 item, scale 1–5)	0.65 (0.47, 0.88)	0.10	0.006
Congestive heart failure	0.27 (0.07, 0.98)	0.18	0.046

Discussion

Higher levels of participation in household physical activity are related to being less socially isolated in older community-dwelling adults. This study also found that older adults' perception of their general health is associated with social isolation, however, of the listed diagnosable medical conditions, only a diagnosis of congestive heart failure was associated with being more socially isolated.

Research has not previously investigated a relationship between specific types of physical activity and social isolation. A possible explanation for a direct relationship between self-reported household-based physical activity and social isolation, but not recreational physical activity, might include the greater probability that an older adult with a cleaner home would be more likely to invite others into their home for social visits, and are therefore, less likely to be socially isolated. Another possible explanation for the relationship between higher levels of household-based physical activity and reduced social isolation in older adults might be that the relationship is actually mediated by another variable, such as physical capacity. That is, higher levels of household physical activity might be associated with higher levels of capacity and hence greater ability to engage in social activities, such as going out to visit friends and family. However, data in this study did not support the relationship between physical capacity and social isolation, and the cross-sectional nature of data in this study makes it difficult to formally test this relationship. Another possible indirect explanation for the relationship between household-based physical activity and social isolation is that the relationship is mediated by depression. Previous research supports a relationship between lower levels of household physical activity and symptoms of depression (Barnes et al., 2006; Pritchard et al., 2015) and results from this study support a relationship between depression and social isolation. However, the reason for the relationship between household-based physical activity and social isolation, based on the findings of this study, is still uncertain. Another consideration is the lack of a finding for a significant relationship between recreational physical activity and social isolation when other variables are accounted for. This might be explained in-part by the relatively lower level of recreational physical activity compared to household-based physical activity reported by the participants in this study. Another possible explanation relates to the type of recreational physical activity being measured. The Phone-FITT questionnaire specifically lists 10 recreational activities typically engaged in by older adults, with the majority of these usually being performed alone (for example, leg weight exercises, other leg strengthening exercises such as standing and sitting, arm weight exercises, other home exercises such as stretching/balance, walking, swimming, cycling and gardening). While the opportunity is provided for older adults to report 'other' types of physical activity they might regularly engage in, the majority of prompts are activities generally performed in isolation rather than with a partner or within a group environment. Therefore, it is perhaps the nature of recreational physical activities typically engaged in by older adults (i.e. lacking in a social component) that have not demonstrated a relationship with social isolation. Further research is recommended to investigate the nature of the relationship between recreational and household-based physical activity with social isolation in older adults to determine whether there is a direct or

indirect relationship. There may be other variables (such as income or education), not examined in this study, that are involved in an indirect relationship between household and/or recreational physical activity with social isolation. Further research in the form of randomised controlled trials would also assist in clarifying the directional nature of such relationships, as it is also possible that older adults who become socially isolated decrease their level of physical activity.

It was theorised that recreational physical activity might be related to social isolation due to the potential for social interaction that accompanies many types of recreational physical activity. It has also been demonstrated that interventions performed within a group environment are more successful at addressing social isolation (Cattan et al., 2005; Dickens et al., 2011). However, the present univariate analyses found that neither participation in group- nor home-based falls prevention exercise were significantly related to social isolation. This finding may be partly due to only 22% and 23% of the respondents respectively participating in group- and home-based falls prevention exercise. Furthermore, details of the programs undertaken were not collected. This may not have been a large enough sample to demonstrate whether falls prevention exercise interventions, as a specific form of physical activity, have an impact on social isolation. Also, the components and intensity of falls exercise may not be suitable for influencing social isolation. Further research is required to investigate whether participation in particular types of group physical activity interventions, such as falls prevention exercise, is related to reduced social isolation.

General health was related to social isolation, in accordance with previous research. Poor health has been demonstrated to be a risk factor for social isolation (Barnes et al., 2006; Iliffe et al., 2007; Jang et al., 2015; Wenger & Burholt, 2004) as is depression (Barnes et al., 2006; Giuli et al., 2012; Iliffe et al., 2007). In addition to better general health being associated with lower levels of social isolation, this paper also found congestive heart disease to be associated with being more socially isolated. Previous research identified lung disease as being related to social isolation, whereas congestive heart disease was associated with increasing loneliness (Step toe et al., 2013). This finding may be due to the differing measures applied to report levels of social isolation. The Friendship Scale includes an item that specifically mentions 'loneliness' therefore making it more likely that socially isolated individuals within this study also experience greater loneliness. Self-reported general health is likely impacted by a persons' mental state. Those reporting better general health are more likely to have better mental health and generally a more positive outlook. It follows then that these individuals would also have reported lower levels of social isolation. The reverse may also be true, that older adults experiencing worse general health likely have less opportunity for social interaction and report higher levels of social isolation. The findings of the present study suggest that interventions to address social isolation need to target those who report worse general health and specifically those with congestive heart failure.

Interestingly, age was not significantly associated with social isolation, contrary to other research findings (Barnes et al., 2006; Edelbrock et al., 2001; Giuli et al., 2012; Ibrahim et al., 2013; Iliffe et al., 2007). Research indicates that social isolation is higher among the oldest-old; however, the present study only included 13% of respondents over 85 years-of-age,

4 participants were over the age of 90, with none being older than 95 years-of-age.

Gender was also not found to be significantly associated with social isolation in the present study. Research findings present conflicting results in relation to the impact of gender on social isolation. Some research suggests females to be more at risk (Barnes et al., 2006; Giuli et al., 2012; Ibrahim et al., 2013), while others demonstrate greater risk among males (Edelbrock et al., 2001; Iliffe et al., 2007; Jang et al., 2015). The findings of the current paper suggest that gender does not influence risk of social isolation. It has been suggested, however, that social isolation is experienced and viewed differently by the sexes (Giuli et al., 2012; Hawthorne, 2008). It has been hypothesised that females are at greater risk for social isolation due to experiencing worse health and physical functioning or the greater likelihood to live alone (Giuli et al., 2012; Ibrahim et al., 2013). However, the measure used to report social isolation may play an important role in gender differences. The Friendship scale is a measure of perception of social isolation. This method of measurement does not take into account number and structure of social contacts, therefore no comparison can be made between the perceived value of social contact experienced between sexes, which may be where the difference lies.

There are several limitations of this study. The respondents had to speak proficient English in order to partake in the telephone surveys; this may have influenced the analysis of ethnicity. The initial sampling of participants included equal numbers of those with and without pre-determined chronic medical conditions and may have led to bias in the relationships with health conditions due to possible over-sampling of some morbidities. The cross-sectional nature of the surveys and reliance on self-reported information are further limitations of this study. Social isolation and physical activity levels were self-reported and as such rely on the honesty and memory recall-ability of participants. There is potential for bias in self-reported results as participants may not have wished to be perceived as socially isolated and consciously responded to questions accordingly. Similarly, for physical activity levels, participants may have reported higher levels of physical activity than they realistically engaged in. The cross-sectional design does not include temporal sequencing and therefore cannot determine the direction of causation in the relationships investigated. Finally, the multivariable model fit was relatively low, suggesting the final model did not describe the data very accurately.

Conclusion

Contrary to expectation, household-based physical activity as opposed to recreational was associated with social isolation in older adults. Further research is required to clarify whether a direct relationship exists or whether this relationship is mediated by other factors. While it appears that group falls prevention exercise was not related to social isolation amongst older adults, study findings reflect the need for future research investigating the impact of group physical activity interventions on social isolation. Older adults with congestive heart disease and those reporting worse general health could be targeted in this research as they were more likely to be socially isolated.

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ORCID

Lauren M. Robins  <http://orcid.org/0000-0002-6727-305X>

Caroline F. Finch  <http://orcid.org/0000-0003-1711-1930>

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