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Gardening as a Potential Activity to Reduce Falls in Older Adults

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This study examines whether participation in gardening predicts reduced fall risk and performance on balance and gait-speed measures in older adults. Data on adults age 65 and older ($N = 3,237$) from the Health and Retirement Study and Consumption and Activities Mail Survey were analyzed. Participants who spent 1 hr or more gardening in the past week were defined as gardeners, resulting in a total of 1,585 gardeners and 1,652 nongardeners. Independent *t* tests, chi square, and regression analyses were conducted to examine the relationship between gardening and health outcomes. Findings indicate that gardeners reported significantly better balance and gait speed and had fewer chronic conditions and functional limitations than nongardeners. Significantly fewer gardeners than nongardeners reported a fall in the past 2 yr. The findings suggest that gardening may be a potential activity to incorporate into future fall-prevention programs.

Keywords: fall prevention, aging, leisure activity

Falls are common among older adults and a major public health concern in this population. The Centers for Disease Control and Prevention (CDC) reported that more than one third of adults over age 65 falls every year (2009). Falls are the leading injury that causes death among older adults (CDC, 2009). Moreover, falls place heavy demands on the health care system. The total cost of fatal and nonfatal fall-related injuries for adults age 65 and older in the United States was more than $19 billion in 2000 (Stevens, Corso, Finkelstein, & Miller, 2006). Englander, Hodson, and Terregrossa (1996) predicted that the cost of fall-related injuries might reach over $85 billion by 2020. These statistics demonstrate that the impact of falls cannot be ignored and the need to explore ways to prevent them is pressing.

Certain sociodemographic characteristics of adults have been associated with falls. Age increases the risk of falls (World Health Organization, 2007). Adults age 85 and over have a rate of fall injury almost 4 times greater than adults age 65–74 (CDC & National Center for Injury Prevention and Control, 2005). Campbell, Borrie, and Spears (1989) found that the risk factors for falls differ among men and women. In their study, a decrease in levels of physical activity, an increase in the rate of chronic conditions such as arthritis and stroke, and impairment of gait increased the risk of falls for men, and the total number of drugs taken, use

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of psychotropic drugs, and muscle weakness increased women's risk of falling. Race has also been associated with falls; being White has been reported as a risk factor (Friedman, Munoz, West, Rubin, & Fried, 2002). In 2005, the CDC noted that there was little difference in the fall rates of Whites and Blacks age 65–74, but Whites are more likely to fall than Blacks after the age of 75.

Tinetti, Speechley, and Ginter (1988) were among the first to suggest that falls in older adults increased as their risk factors increased. Several physical health and function characteristics have since been identified as common risk factors of falls, including poor balance and gait (Bassey, 2005; Robbins et al., 1989; Wolfson et al., 1996), functional limitations (Tromp et al., 2001), and chronic conditions (Lawlor, Patel, & Ebrahim, 2003; Maurer, Burcham, & Cheng, 2005; Tutuarima, van der Meulen, de Haan, van Straten, & Limburg, 1997). This suggests that proper interventions targeting these physical-function risk factors for falls have the potential to reduce the incidence of falling among the aging population.

Research indicates that exercise and physical activity may be one approach to decreasing risk factors of falls and reducing the incidence of falling for older adults. Moderate-intensity (Hall, Maher, Latimer, & Ferreira, 2009) and high-intensity (Fiatarone et al., 1990) exercises have been noted to provide benefits to reduce risk factors for falls. However, a study by Peeters et al. (2010) indicated that high-intensity sports or activities are associated with an increased risk of falling. Overall, physical activity has been associated with having a positive effect on balance (Marigold et al., 2005), gait (Daley & Spinks, 2000; Durstine et al., 2000), functional limitations (Cavanaugh, Coleman, Gaines, Laing, & Morey, 2007), chronic conditions (Pedersen & Saltin, 2006), and the incidence or risk of falls (Gregg, Pereira, & Caspersen, 2000). Several fall-prevention interventions have emerged in the last several years; some focus on exercise alone, and others integrate exercise and physical activity into multifactorial approaches. A recent study comparing these two types of interventions suggested that exercise-alone fall-prevention approaches may be more valuable from a cost-efficiency and public health perspective (Petridou, Manti, Ntinapogias, Negri, & Szczerbinska, 2009). Most of the research on specific physical activities and fall risk has explored the effects of Tai Chi (e.g., Hall et al., 2009; Hong, Li, & Robinson, 2000; Wooton, 2010) in successfully reducing the incidence of falls among older adults. However, yoga (DiBenedetto et al., 2005; Omkar, Vishwas, & Tech, 2009; Silver, 2005) and dance-based (Keogh, Kilding, Pidgeon, Ashley, & Gillis, 2009; McKinley et al., 2008) interventions are increasingly evident in the literature, as well.

Tai Chi, yoga, and dancing are all typically classified as moderate-intensity physical activities. The main reason that these activities may reduce the incidence of falls in older adults is that at least some element of the activity focuses on balance. There is an indication that exercise can prevent falls in community-dwelling older adults as long as the activity challenges their balance (Sherrington, Lord, & Finch, 2004). A recent review of studies exploring Tai Chi as a means of preventing falls in older adults suggested that this physical activity may be particularly beneficial through its effect on balance (Wooton, 2010). Research also suggests that dancing can significantly improve the balance and gait of older adults and thus reduce their prevalence of falls (Keogh et al., 2009). The evidence related to yoga is less clear, but research suggests that it may improve adults' balance, core strength, flexibility

(Omkar et al., 2009; Silver, 2005), and gait through increased stride length and hip extension (DiBenedetto et al., 2005).

Gardening has been cited as one of the activities older adults most commonly engage in (Ashton-Shaeffer & Constant, 2005; DiPietro, 2001). A study by Stoneham and Jones (1997) reported that 94% of older adults had lived most of their lives with a garden. Gardening is generally characterized as a moderate-intensity activity, which is approximately 3–6 metabolic equivalents (METs; Ainsworth et al., 2000; Park, Shoemaker, & Haub, 2008; Pate et al., 1995), and it has been used as a therapeutic modality since the 1920s (Davis, 1997). A study by Park, Shoemaker, and Haub (2008) on older adult gardeners reported that they typically spend over 50 min at a time gardening and garden an average of 33 hr/week in May and 15 hr/week in June and July. The definition of gardening ranges from plant growing to a leisure or recreational activity to a vocational pursuit (Riordan, 1983). It can be divided into a variety of subtasks including moving plants, carrying plants to table level, potting plants, managing plants in the pot, and watering (Relf, 1981). These subtasks of gardening have the potential to provide health benefits and target balance, because they require weight-bearing motions, muscle coordination and motor skills, and shifts in the center of gravity.

In addition, the format of gardening may also influence the associated benefits of this activity. Cyarto, Brown, Marshall, and Trost (2008a) examined home-based versus group-based physical activities and found significantly improved static balance in the group-based program participants, whereas home-based program participants reported greater improvements in balance confidence. These same researchers (Cyarto, Brown, Marshall, &Trost, 2008b) also noted that participants in group-based resistance-training programs experienced significant improvements in strength, lower body flexibility, and dynamic balance, and individuals in a home-based group significantly improved their strength and upper body flexibility. Thus it appears the format and location of some physical activities may influence the health-related benefits that are experienced, and this may also be a factor for gardening. Although gardening is typically considered a home-based physical activity, use of community gardens or the integration of gardening into intervention programs could potentially be structured more as a group-based physical activity.

Most of the research on gardening has focused on its psychological, mental, or social health benefits (e.g., Carman, 2006; Di Mauro et al., 2001); however, research has also suggested that gardening may benefit adults' physical health and function. Wichrowski, Whiteson, Haas, Mola, and Rey (2005) reported an indirect effect of gardening for controlling heart rates of patients with cardiac disease. Cooper, Barker, and Wickham (1988) found a relationship between participating in gardening and a reduced risk of hip fracture across sex in older adults. Gardening has also been associated with controlling cholesterol and systolic blood pressure (Caspersen, Bloemberg, Saris, Merritt, & Kromhout, 1991) and improving diabetes care (Armstrong, 2000). Turner, Bass, Ting, and Brown (2002) indicated that many gardening and yard-work tasks such as pushing a mower, digging holes, and pulling weeds require weight-bearing motions and use the entire body and as such can be expected to maintain bone-mineral density in older adults. Research has suggested that over 82% of gardeners bend, 59% walk, and 47% lift for durations of 10 s or longer when involved in this activity (Park & Shoemaker, 2009). Research on

community gardens indicates that they have the potential to improve the health of at-risk and urban populations through better nutrition, as well as physical activity (Kingsley, Townsend, & Henderson-Wilson, 2009; Stein, 2008).

Few studies have examined the association between gardening and physical health. Several studies include gardening in their analyses of physical activity but group it together with other household (e.g., Chan et al., 2007) or productive (e.g., Menec, 2003) activities. By classifying gardening with other activities such as housework and volunteering, these studies are unable to discern the effects of gardening specifically on older adults' health and well-being. Although household activities might have levels of energy expenditure similar to gardening, there are many ways that these activities may differ in terms of the physical abilities required and meaning or enjoyment gained as a result of involvement. In the few studies that specifically explored gardening, the activity was often measured in different ways. Some studies measured gardening qualitatively (e.g., Wakefield, Yeudall, Taron, Reynolds, & Skinner, 2007) and thus provided subjective perceptions of gardening, its meaning, and its association with adults' health and well-being. Other studies (Brown, Allen, Dwozan, Mercer, & Warren, 2004; Park & Shoemaker, 2009) have relied on more quantitative measurements of gardening involvement, but the frequency of gardening was not assessed in a consistent manner, making it more difficult to compare the findings from these studies and determine a minimum level of participation necessary to obtain health benefits.

The benefits of gardening on adults' physical, psychological, mental, and social health have been documented in the literature. However, little to no research has specifically focused on the relationship between gardening and physical-functioning measures related to falls in the aging population. Because many older adults participate in gardening activities to improve their physical fitness (Ashton-Shaeffer & Constant, 2005), it is possible that gardening is a modality that could be used to reduce the incidence of falling in this population through its ability to improve aspects of balance and gait. To address this gap in the literature, this study examined whether participation in gardening predicts reduced fall risk and performance on measures of balance and gait speed in older adults.

Method

Participants

The data were retrieved from the Health and Retirement Study (HRS; 2006) and the Consumption and Activities Mail Survey (HRS, 2005) sponsored by the National Institute on Aging (grant number U01AG009740) and conducted by the University of Michigan. Participants who were under 65 years old and data reported by a proxy were excluded from the study. Only individuals in the supplemental CAMS data set were included in these analyses. The total sample size for this study was 3,237 individuals with ages ranging from 65 to 101 years ($M = 74.20$, $SD = 7.09$). In this sample, most of the participants were women (53%) and the race was predominantly White (88.4%). In terms of education, 22.6% of the sample reported having received no formal educational degree, 54% had completed high school or received their general equivalency diploma, and 8.2% had received a graduate or professional degree.

Measures

Balance. Three balance tests were used to evaluate static balance, including the side-by-side, semitandem, and full-tandem balance tests. An interviewer from the HRS objectively measured the participants' performance on these tests. The balance tests were conducted in the participants' homes in an area where the floor was level and preferably with no or low-pile carpet (Crimmins et al., 2008). These tests ranged in difficulty; the easiest was the side-by-side test and the most difficult was the full-tandem test. The participants were first asked to perform the semitandem stance (stand with the big toe of one foot touching the side of the heel of the other foot) for 10 s. If successful in completing this stance, they were next asked to perform the full-tandem stance (stand with the big toe of one foot touching the back of the heel of the other foot) for 30 s. If the participants failed to successfully complete the semitandem stance, they were asked to perform the side-by-side stance (stand with both feet together) for 10 s. Good to excellent reliability and predictive validity have been found for these balance tests (Jette, Jette, Ng, Plotkin, & Bach, 1999; Perera, Mody, Woodman, & Studenski, 2006). The goal of the test is to maintain balance in the most difficult stance possible for the full amount of time. In this study, these variables were coded as 1 (able to successfully complete the stance) or 0 (unsuccessful in the stance or stance not tested). In this sample, 38.8% of participants successfully completed the semitandem stance. Of those who attempted the full-tandem stance only 25.6% were successful; of the adults who were asked to complete the side-by-side stance only 3.5% were successful.

Gait. The timed walk test was conducted with each respondent in the HRS and is used to objectively evaluate gait speed. For each participant completing the test, the HRS interviewer set up a walking course in the individual's home, preferably in a space that was clear and uncarpeted (Crimmins et al., 2008). Each participant was asked to walk 2.5 m two times, up (Trial 1) and back (Trial 2), while wearing proper footwear. Adults who regularly use an assistive device while walking were allowed to use the aid during the test. The timed walk test is measured in seconds; the faster the participant walked, the better he or she performed on the gait-speed test.

Falls. In the HRS interview, the participants were asked if they had fallen in the past 2 years. This variable was coded as 1 (reported a fall) or 0 (no falls reported). Slightly less than one third of the sample (31.1%) reported falling in the last 2 years. This is comparable to statistics on falls among community-dwelling adults in other studies (e.g., Bergland & Wyller, 2004).

Chronic Conditions. The first self-reported measure of health status in the study was based on each respondent's chronic conditions. Individuals were asked if they had been informed by a doctor that they had any of the following chronic diseases: high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, or arthritis. A composite score measuring the total number of chronic conditions for each participant was calculated by adding up the number of chronic disease diagnoses. The average number of diagnoses per participant was 2.19, with a range of 0–7. The most commonly reported chronic conditions in this sample were arthritis (68.8%) and high blood pressure (64.1%); only 8% of respondents had experienced a stroke.

Functional Limitations. The second self-reported measure of health status in this study was the adults' report of functional limitations. In the HRS interview, the respondents were asked if they had difficulty performing several functional activities including walking several blocks, getting up from a chair, climbing stairs, stooping, reaching their arms above the shoulders, pulling and pushing objects, lifting weights, and walking. A composite score of functional limitations was calculated for each participant by adding up the functional limitations noted. On average, the respondents in this sample noted having difficulty with slightly more than two functional abilities ($M = 2.19$, $SD = 2.21$).

Gardening. In the CAMS supplement of the HRS interview, the participants were asked how many hours they actually spent on yard work or gardening during the last week. Because of the large number of participants who did not participate in this activity (49.5%) or participated minimally, this variable was dichotomized. Participants who reported spending less than 1 hr/week gardening were classified as nongardeners, and those who reported at least 1 hr/week of involvement in gardening were classified as gardeners. The gardeners in this sample had spent anywhere from 1 to 47 hr gardening or doing yard work in the past week, averaging 4.8 hr in the activity (mode = 2 hr, median = 3 hr). For the purpose of these analyses, gardeners were coded as 1 and nongardeners as 0.

Sociodemographic Characteristics. Several sociodemographic characteristics that have been associated with falling among older adults were included in this study. Age was measured as a continuous variable. Gender and race were also assessed with dummy-coded variables, with men and Whites as the reference categories. Education was measured in terms of the highest degree obtained by the respondents and included seven categories of educational attainment: 1 = *no degree* to 7 = *professional degree* (PhD, MD, or JD).

Analytical Procedure

Independent *t* tests and chi-square analyses were performed to explore whether there were differences in balance, gait speed, functional limitations, chronic conditions, and the number of reported falls in the past 2 years between the gardeners and nongardeners. Regression analyses were conducted to examine the relationship between gardening and physical function in this sample. First, ordinary least-squares regression was used to test whether engaging in gardening activities was a predictor of gait speed, functional limitations, and chronic conditions. Logistic regression was employed to examine whether engaging in gardening activities could predict completion of the three balance tests and the incidence of falls. Covariates known to influence these outcome variables were controlled for in the regression analyses. All analyses were performed using SPSS version 18.0 statistical software for Windows.

Results

Differences Between Gardeners and Nongardeners

In terms of sociodemographic characteristics, gardeners ($M = 73.19$ years, $SD = 6.20$) were significantly younger than nongardeners ($M = 75.17$ years, $SD =$

7.75) by an average of approximately 2 years, $t(3,132) = 8.05$, $p \leq .001$, $d = -.28$, 95% CI –0.35, –0.21. Gardeners were also more likely to be male and White. No significant difference in gardening status was evident by educational attainment. Overall in terms of health status, gardeners reported better physical functioning and performance. Nongardeners noted significantly more chronic conditions, $t(3,232) = 6.13$, $p \leq .001$, $d = -.22$, 95% CI –0.29, –0.15, and more functional limitations, $t(3,220) = 8.94$, $p \leq .001$, $d = -.31$, 95% CI –0.38, –0.24, than gardeners. There were significant differences between the two groups on all the balance measures: semitandem, $\chi^2(1, N = 3,237) = 22.68$, $p \leq .001$, OR = 1.41, 95% CI 1.22, 1.63; side-by-side, $\chi^2(1, N = 3,237) = 7.54$, $p \leq .01$, OR = 0.58, 95% CI 0.39, 0.86; and full tandem, $\chi^2(1, N = 3,237) = 45.35$, $p \leq .001$, OR = 1.73, 95% CI 1.47, 2.03. In all the tests except the side-by-side stance, more of the gardeners than nongardeners successfully completed the balance test. The groups differed significantly on both gait trials—Trial 1: $t(1,014) = 5.77$, $p \leq .001$, $d = -.34$, 95% CI –0.41, –0.27; Trial 2: $t(983) = 6.78$, $p \leq .001$, $d = -.39$, 95% CI –0.46, –0.33—with gardeners walking faster at both time points than nongardeners. Gardeners were significantly less likely to report a fall in the previous 2 years, $\chi^2(1) = 21.85$, p £ .001, OR = 0.69, 95% CI 0.60, 0.81. The results of these analyses and differences in gardening by sociodemographic variables are reported in Table 1.

Relationship Between Gardening and Health Status

Regression analyses were performed to explore whether being a gardener predicted better health status in this sample. The models predicting chronic conditions, $F(5, 3,236) = 23.08$, $p \leq .001$, $\eta^2 = .03$, 95% CI –0.32, –0.14, and functional limitations, $F(5, 3,236) = 53.06$, $p \leq .001$, $\eta^2 = .08$, 95% CI –0.61, –0.32, were both significant. Being a nongardener was a significant predictor of more chronic conditions ($b = -.09$, $p \leq .001$) and functional limitations ($b = -.11$, $p \leq .001$). Other significant predictors of worse health status included older age, being White, and having less education. Being male was associated with more functional limitations but not more chronic conditions. Given that involvement in physical activity promotes physical function, the relationship between gardening and the health status measures cited here is not surprising. Thus, the next step in this study was to determine whether gardening was significantly related to functioning in gait speed and balance in older adults, main risk factors predicting falls in this population.

Relationship Between Gardening, Risk Factors Related to Physical Function, and Falls

Regression analyses controlling for functional limitations and chronic conditions, as well as sociodemographic characteristics associated with falls (i.e., age, gender, race, and education), were conducted. First, ordinary least-squares regression analysis was used to determine whether gardening was a significant predictor of gait speed at Trial 1 and Trial 2. Next, a series of logistic-regression analyses was performed to investigate the relationship between gardening and the three measures of balance and falls. The results from these analyses are presented in Table 2.

The results of the regression analyses suggest that participation in gardening does influence several risk factors for falls. Being a gardener was a significant

Table 1 Characteristics of Gardeners and Nongardeners

	Gardeners[a] (*n* = 1,585)			Nongardeners[b] (*n* = 1,652)					
Variable	**%**	***M***	***SD***	**%**	***M***	***SD***	***t* Test or chi-square**	**Effect size (*d* or OR)**	**95% CI**
Age		73.19	6.20		75.17	7.75	$t(3,132) = 8.05$**	–0.28	–0.35, –0.21
Gender: male	57.4			36.7			$\chi^2(1) = 138.77$**	2.32	2.01, 2.67
Race: White	91.3			85.6			$\chi^2(1) = 25.60$**	1.76	1.41, 2.20
Chronic conditions		2.05	1.21		2.33	1.29	$t(3232) = 6.13$**	–0.22	–0.29, –0.15
Functional limitations		1.96	1.97		2.61	2.19	$t(3,220) = 8.94$**	–0.31	–0.38, –0.24
Balance (completed)									
semitandem	43.0			34.8			$\chi^2(1) = 22.68$**	1.41	1.22, 1.63
side-by-side	2.6			4.4			$\chi^2(1) = 7.54$*	0.58	0.39, 0.86
full tandem	30.9			20.5			$\chi^2(1) = 45.35$**	1.73	1.47, 2.03
Gait									
Trial 1 (s)		3.54	1.63		4.27	2.58	$t(1,014) = 5.77$**	–0.34	–0.41, –0.27
Trial 2 (s)		3.27	1.44		4.05	2.38	$t(983) = 6.78$**	–0.39	–0.46, –0.33
fell in past 2 years	27.3			34.9			$\chi^2(1) = 21.85$**	0.69	0.60, 0.81

[a]Participants who reported gardening 1 hr or more in the past week. [b]Participants who did not garden in the past week or were involved for less than 1 hr.

*$p \leq .01$. **$p \leq .001$.

Table 2 Linear- and Logistic-Regression Analyses of Predictors of Gait and Balance

			Semitandem		Side-by-Side		Full Tandem	
Variable	**Gait Trial 1, β**	**Gait Trial 2, β**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Age	0.26***	0.24***	0.97***	0.96, 0.98	1.07***	1.04,1.10	0.95***	0.94, 0.96
Gender: male	–0.07**	–0.05*	1.15	0.99, 1.33	0.80	0.54, 1.20	1.27**	1.07, 1.50
Race: White	–0.13***	–0.11***	1.29*	1.02, 1.63	0.95	0.53, 1.72	1.07	0.82, 1.40
Education	–0.14***	–0.14***	1.04	0.99, 1.09	0.97	0.85, 1.10	1.09***	1.03, 1.15
Chronic conditions	0.03	0.01	0.95	0.89, 1.01	1.31***	1.12, 1.54	0.88***	0.82, 0.94
Functional limitations	0.15***	0.15***	0.95*	0.91, 0.98	1.20***	1.09, 1.31	0.91***	0.87, 0.95
Gardening status: gardener	–0.09***	–0.13***	1.22**	1.05, 1.41	0.91	0.60, 1.39	1.40***	1.19, 1.66
R^2	0.19	0.18	—		—		—	
F	43.36***	39.88***	—		—		—	
χ^2	—	—	99.21***		86.91***		206.76***	

*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

predictor of gait speed at Trial 1 ($b = –.09$, $p \leq .001$) and Trial 2 ($b = –.13$, $p \leq .001$) and performance in the semitandem (OR = 1.22, $p \leq .001$) and full-tandem balance tests (OR = 1.40, $p \leq .001$), even after controlling for the respondents' health status and sociodemographic characteristics in the analyses. Thus, older adults who garden had faster gait speed at Trial 1 and Trial 2. Gardening also increased the odds that older adults would successfully complete the semitandem balance stance by almost 22% and the odds of successfully completing the full-tandem balance test by 40%, controlling for other variables in the model. Gardening status was not significantly associated with successful completion of the side-by-side balance test; however, age, number of chronic conditions, and functional limitations were significant factors in this model.

Finally, a logistic regression was conducted that controlled for health status (i.e., functional limitations and chronic conditions), balance, and gait speed to assess whether gardening was a significant predictor of falls. Significant factors associated with falling in the past 2 years included race (OR = 1.69, $p \leq .05$), functional limitations (OR = 1.19, $p \leq .001$), gait speed at Trial 1 (OR = 1.23, $p \leq .05$), and the full-tandem balance stance (OR = 0.67, $p \leq .01$). Specifically, being White increased the odds of an older adult falling by approximately 69%. For each additional difficulty reported with functional limitations, an older adult's odds of falling during the past 2 years increased by almost 20%, and for each additional second required to walk the first trial of the gait test an older adult's odds of falling increased by 23%. Being able to successfully complete the full-tandem balance stance for the required 30 s reduced the odds that the older adult would report a fall in the past 2 years by a factor of .67 when controlling for other variables in the model (see Table 3 for complete results). Gardening was not a significant predictor of falls in this model. The results from this analysis suggest that gardening was indirectly related to a reduced risk for falls among older adults through its relationship with the fall-

Table 3 Logistic-Regression Analysis Examining Different Risk Factors for Falling in the Past 2 Years in Older Adults

Variable	OR (exp[B])	95% CI
Age	0.99	0.97, 1.01
Gender: male	0.99	0.77, 1.28
Race: White	1.69*	1.04, 2.73
Education	1.07	0.98, 1.16
Chronic conditions	1.08	0.97, 1.16
Functional limitations	1.19***	1.12, 1.28
Gardening status: gardener	0.87	0.67, 1.13
Gait Trial 1	1.23*	1.03, 1.47
Gait Trial 2	0.84	0.69, 1.02
Semitandem balance stance (completed)	0.56	0.27, 1.17
Side-by-side balance stance (completed)	0.99	0.44, 2.20
Full-tandem balance stance (completed)	0.67**	0.57, 0.89
χ^2	105.79***	

*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

risk factors of balance, gait speed, functional limitations, and chronic conditions rather than directly affecting fall rates of adults.

Discussion

To our knowledge this was the first study investigating the relationship between gardening and incidence of falls. Our findings indicate that gardening is associated with better health status in terms of the number of chronic conditions and functional limitations reported by older adults. Gardening was also a significant predictor of performance in the semitandem and full-tandem balance tests, as well as gait speed, of the older adults in this study. We found that gardening did not directly influence the incidence of falls when controlling for these main risk factors. However, the relationship between gardening and these health and physical-functioning measures suggests that it may potentially influence the fall risk of older adults through its effect on their health status, balance, and gait speed.

As research has demonstrated, reducing risk factors for falls significantly reduces the incidence of falls (CDC, 2008). The results of this study indicate that gardening may potentially be a modality to achieve this goal. However, older adults should take precautions when gardening. Chan et al. (2007) found that fall risk was attributable to household physical activities including housework, gardening, and home repair; high levels of physical activity in these activities was associated with a greater fall risk. Another study indicated that falls often occur in the person's own garden and that more men (25%) than women (11%) report a fall while gardening (Campbell et al., 1990). For these reasons, it is important to plan and implement gardening programs carefully if they are to be integrated into fall-prevention programs. It is possible that group-based gardening programs, either through community gardens or residential living facilities, would be a safer mechanism in which to offer this intervention, because more monitoring of the adults' risk taking in this physical activity beyond the individuals' ability would be possible, a factor that has been associated with falls in the literature (de Rekeneire et al., 2003). With proper adaptation (Kwack, Relf, & Rudolph, 2004), gardening could be applied in a variety of settings and with groups of adults with a wide range of functioning levels.

The results from this study suggest that gardeners are more likely to be younger, male, and White. Other studies have reported that gardening is slightly more common among women (Ashton-Shaeffer & Constant, 2005); the difference in this study might be attributed to the fact that yard work was also included in the category of gardening, and this activity may be more common among men. Di Mauro et al. (2001) found that as people's education levels increase they spend less time on gardening; however, this was not noted in the current study. The findings from this study regarding gardening and health benefits support previous research indicating that this activity is associated with greater levels of physical function and better physical health (Park & Shoemaker, 2009; Park et al., 2008; Turner et al., 2002).

Although gardening itself was not a significant predictor of falls, it was significantly associated with all the fall-risk factors examined in this study. The only sociodemographic characteristic that predicted falls in this study was race, with White older adults having significantly greater odds of falling. This is comparable

to the findings of Friedman et al. (2002). However, unlike other studies (e.g., Sattin, 1992), age was not a significant predictor of falls once other risk factors were accounted for in this study. Like participation in gardening, age was significantly associated with measures of health status and function in this sample. Although gardeners in this study were younger than the nongardeners, the average age of both groups was in the mid-70s, so it is unlikely that age-related health declines were a significant factor in determining these individuals' participation in gardening. Thus, the relationship between age and gardening needs to be examined more closely to better understand the relationship between gardening, age, and fall-risk factors.

As a moderate-intensity activity, gardening is different from Tai Chi, yoga, and dance. Although it is viewed as a productive and purposeful activity, the different subtasks of gardening (e.g., watering, potting, carrying plants) may have the ability to strengthen balance and gait speed. However, *gardening* is a very broad term that incorporates mowing lawns, planting seedlings, planting trees, and even picking flowers, fruits, or vegetables (Ainsworth et al., 2000). Different types of gardening should affect adults' balance and gait in different ways. This leads to a great deal of variability in the subtasks performed by older adult gardeners and the physical ability required for each of these subtasks. Nonetheless, one positive aspect of gardening is that it could be tailored so that adults could advance to more difficult types of gardening as they become more comfortable and competent with the easier tasks. This would allow an opportunity for progression in physical challenge, which would likely help further improve their health and functioning and reduce their risk of falling.

Limitations of the Study

One limitation of this study is the limited measurement of gardening. The types of gardening activities that the participants engaged in are not clear because they were not assessed in the HRS data set. Other studies have measured gardening through self-developed garden skill tests (Heliker, Chadwick, & O'Connell, 2000), assessments of the meaning of gardening (Wakefield et al., 2007), the frequency of gardening participation (Brown et al., 2004), or the level of independence of the individual while gardening (Thelander, Wahlin, Olofsson, Heikkilä, & Sonde, 2008). However, to more accurately examine the effects of gardening and determine which subtasks are the most beneficial, a randomized controlled trial is recommended.

Similarly, the definition of a fall was not clearly provided by HRS. Wolf et al. (2003) found that applying different fall definitions when measuring falls among the same sample can lead to different results. In their research, when applying the definition of falls from Frailty and Injuries: Cooperative Studies of Intervention Techniques, 209 falls were noted. However, when applying the narrower Atlanta definition, 110 falls were noted. Thus, there are different definitions of falls, and the interviewer's and respondent's definition of falls can influence the reports of falls. During the HRS interview, the interviewees were asked only "How many times have you fallen in the past 2 years?" without providing more information about what constitutes a fall. It is possible that a stumble or trying to regain balance in a lower posture level might have been ignored or included erroneously as a fall, depending on the interviewer.

Spirduso (1995) described dynamic balance as maintaining center of gravity within the base of support when moving forward, backward, or sideways, such as reaching for objects or pressing the elevator button. Several subtasks of gardening (e.g., moving plants and carrying plants to table level) challenge dynamic balance. However, the balance test used by HRS only tests static balance. Therefore, the effects of gardening on dynamic balance were not examined in this study. Both static and dynamic balance are predictors of falls (Lord, Sherrington, Menz, & Close, 2007), so future studies should incorporate tests of both types of balance in their measurements.

Overall, this study found that gardening may influence the incidence of falls in older adults through its relationship to the fall-risk factors of chronic conditions, functional limitations, gait speed, and balance. This study has several practical implications for the older adult population. Gardening is a health-promoting activity that can be implemented in a variety of settings with older adults and with samples of adults with a range of physical and even cognitive abilities. This activity may be suitable to use in fall-prevention interventions, similar to other types of moderate-intensity activities such as Tai Chi and dance. Not only is this an activity that many older adults enjoy and are familiar with, it also appears to be significantly associated with better balance, better gait speed, and fewer functional limitations in the aging population.

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