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Exercise and cognition: Results from the National Long Term Care Survey

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Abstract

Background—Age remains a robust risk factor for Alzheimer's disease as well as other dementias. Therefore, the aging of the population in the United States will result in dramatic increases in the prevalence of dementia if preventative interventions are not identified. The aim of this study was to examine potential associations between exercise and lowering the risk of cognitive impairment.

Methods—National Long Term Care Survey (NLTC) data were used. Level of exercise participation was measured at baseline (1994) and cognitive impairment status was measured at baseline and 5- and 10-year follow-up. Linear regression was performed, controlling for age, sex, education, baseline score on cognitive test, diabetes and hypertension.

Results—At 10-year follow-up, the number of different types of exercises performed was inversely associated with the onset of cognitive impairment ($p=0.002$) as was the number of exercise sessions lasting at least 20 minutes ($p=0.007$).

Conclusion—Study results from NLTC data provide evidence supporting the potential for exercise to lower the risk of dementia.

Keywords

exercise; physical activity(ies); cognitive impairment; cognition; dementia

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1. Introduction

As older adults live longer and the baby boomer cohort ages, we are experiencing a demographic revolution in the United States (US). The number of people age 85 and older is rapidly increasing and individuals born from 1946 to 1964, the Baby Boomers, are reaching their 60's; both groups contributing substantively to this demographic shift [1,2]. In general the prevalence of disability for those age 65 and older has been steadily dropping since 1982 [3]. However, the risk for Alzheimer's disease (AD) and other dementias increases rapidly with age. Thus, the graying of the population will give rise to dramatic increases in the prevalence of dementia [4,5] unless interventions and strategies to prevent or delay the onset of dementia, or slow its progression, are identified, tested and implemented.

Physical activity shows promise as a potential intervention to favorably impact cognitive function and perhaps lower the risk of dementia. Although several studies provide support for an association between physical activity and cognitive function [6-8], as well as dementia [9-11], others did not find a statistically significant association [12-15]. Of those not finding a significant association, none had sample sizes $\geq 1,000$.

Several randomized trials provide further support for physical activity as a potential cognitive intervention [16,17], although their sample sizes were small. Two trials randomly assigned older study subjects to either an aerobic (walking) or anaerobic (stretching and toning) intervention. After 6 months, those in the aerobic groups outperformed control (anaerobic) subjects on tests of executive functioning [16,17]. In a third trial, subjects were randomly assigned to one of four groups: aerobic training, mental activity training, combined aerobic and mental activity training, or control; memory improved for those in the aerobic training groups [18]. A recent randomized trial assessed the effects of exercise on cognitive function for subjects without dementia but with reported memory difficulties. Results indicated improved cognitive function at follow-up [19]. In a randomized trial with older study subjects who had sustained a fall, findings indicated that those assigned to a balance, strength and walking exercise program improved in executive function while the control group deteriorated [20].

Animal studies provide additional substantiation of the potential for exercise to improve cognitive function. Mice utilizing running wheels in their cages showed improved memory [21] while learning was enhanced through exercise for older beagle dogs [22].

In this study we used data from three Waves (1994, 1999 and 2004) of the National Long Term Care Survey (NLTCS) to examine potential associations between physical activity and cognitive health (i.e. cognitive function and cognitive impairment).

2. Methods

The NLTCS is a large, nationally-representative dataset. It was initiated in 1982 by the Health Care Financing Administration, now the Center for Medicare and Medicaid Services (CMS), to assess the health of the elderly and their needs for long-term care. A follow-up survey was conducted in 1984. In 1989, the National Institute on Aging (NIA) took over funding for the NLTCS thus establishing 5-year intervals for follow up. Additional surveys were undertaken in 1994, 1999 and 2004. Since 1984, both community-residing and institutionalized study subjects have been included in the sample, which is selected from Medicare enrollees.

Three Waves of NLTCS data were used for this study: 1994, 1999 and 2004. Only subjects who received the Community Questionnaire in 1994 (baseline) were included in our sample (N=5,280) because data on physical activity were not collected for subjects who were living in an institution. Subjects who reported (or a proxy reported) having AD, senility or mental

retardation in 1994 (N=31) were excluded. In 1994, subjects were given the Short Portable Mental Status Questionnaire (SPMSQ) [23]. Subjects making 2 or fewer errors were considered intact; those with 3 to 4 errors were considered mildly impaired; those with 5 to 7 errors were considered moderately impaired and subjects making 8 to 10 errors, with 10 as the maximum number of errors possible, were defined as severely impaired. Scoring for the SPMSQ was adjusted for education with one additional error allowed for those with less than a high school education and one fewer error permitted for those with educational levels beyond high school. Subjects with SPMSQ scores in 1994 indicating severe or moderate cognitive impairment (N=519) were excluded, as were respondents with missing values for the SPMSQ in 1994 (N=898), leaving a baseline sample size of 3,863. Of these, 1,177 were deceased and 198 were lost to follow-up by 1999, leaving 2,488 (See Figure 1); by 2004, 2,253 were deceased and 350 were lost to follow-up, leaving 1,260 (See Figure 2). These data include updated information on mortality. (Personal communication from Vicki Lamb, April 28, 2008)

In 1999, surviving subjects living in the community were given the Mini-Mental State Exam (MMSE) [24]. Subjects with a score of 24 and above were considered intact (N=1,448); 115 subjects were mildly impaired. There were 179 with scores below 20, suggesting at least moderate impairment. The 2004 community questionnaire again included the SPMSQ (intact=862; mildly impaired=80; moderately/severely impaired=96). In 1999, 23.4% of those receiving the community questionnaire lack a MMSE score. In 2004, only 5.8% were missing SPMSQ scores.

We also examined living status/level of independence as a global measure of functioning related to cognitive impairment. Subjects were divided into four groups: living in the community without a caregiver (N=1,660 in 1999 and 712 in 2004), living in the community with a caregiver (N=613 in 1999 and 390 in 2004), institutionalized (N=215 in 1999 and 158 in 2004) and deceased. These outcomes are perhaps more objective measures than the cognitive test scores and they are directly related to the costs and burdens associated with dementia. This analysis is particularly useful for the five-year follow-up because of the high proportion that did not receive the MMSE.

The 1994 Wave of the NLTCs provides detailed information about participation in 23 physical activities. Questions include whether or not the subject participated in the activity; if so, how often during the previous two-week period and the number of minutes per session of activity. Questions were rescaled to a one-week period to ease interpretation of the results. Using this information, we scored our independent variable of interest, level of physical activity participation at baseline, using several different methods. First we calculated the number of different physical activities each subject undertook. Next we totaled the number of minutes spent per day performing all physical activities combined. We also calculated the number of minutes per day spent walking for exercise and gardening/yard work, the two most common physical activities. Periods of exercise below 10 minutes per session (too little) were set to zero and those above 60 minutes per session (excessive or a data entry error) were capped at 60 minutes. If an individual reported doing a particular type of exercise during the past two weeks but values on the time per session were missing (about 1% of reports), time was set to zero. To determine whether or not there was a threshold effect, we calculated the number of sessions per week spent exercising at least 20 minutes and the number of sessions that were 10 to < 20 minutes.

2.1. Data analysis

Analysis of the 1999 data was based on a linear regression of MMSE scores on the baseline SPMSQ score, with controls for age, sex, education, relevant medical conditions (presence of diabetes [25] or hypertension [26]) and various measures of the amount of exercise. The regressions were estimated using an "errors-in-variables" model that controls for the reliability

of the SPMSQ and the reports on exercise. The reliability of the SPMSQ was set at 0.82 based on the original validation study [23]. The reliability of the exercise measures were set at 0.75. This is a slightly higher value than the 0.67 found by the Women's Health Initiative [27] and much higher than the 0.43 reported for hours of bicycle riding reported in a study of risk factors for breast cancer in German women [28]. Controlling for the reliability of the exercise reports increased both the parameter estimates and the standard errors of the estimates leaving the significance levels virtually unchanged.

The 2004 data were analyzed using a linear regression on change in the SPMSQ score between 1994 and 2004. The regression controlled for the baseline SPMSQ, age, sex, education, relevant medical conditions (diabetes and hypertension) and various measures of exercise. Errors-in-variables adjustments were made for the reliability of the baseline SPMSQ and the exercise variables as described above [29].

The data on living status (without caregiver, with caregiver, in an institution or deceased) in 1999 and 2004 were analyzed using multinomial logistic regression and included age, sex, education and marital status as controls.

3. Results

Table 1 presents the characteristics of the total sample in 1994, as well as subjects with SPMSQ scores in 1994 and subjects who were cognitively intact/mildly impaired at baseline. The characteristics of those with SPMSQ scores were similar to the total sample. As would be expected, about two-thirds were female. About one-third were aged 75-79. Of the total sample, 66.7% had at least some high school education. The cognitively intact/mildly impaired group had a slightly higher level of education (70.2% with at least some high school).

Baseline characteristics of those who reported exercising for an average of at least 10 minutes per session compared to those who reported not exercising for at least 10 minutes per session, on average, are shown in Table 2. Those who reported exercising tended to be younger when compared to those who did not exercise although the majority in both groups was age 75-79. Those who reported exercising also tended to be more highly educated (28.9% reported at least some college). Over half of each group were male, but almost three-quarters of the non-exercisers were male (73.9%). Those who exercised were more likely to be cognitively intact at baseline.

The reports of physical activities in 1994 are summarized in Table 3. Overall, 47.4% reported that in the past two weeks they had engaged in at least one type of exercise for an average of 10 minutes or more per session. Those who reported exercising stated that they engaged in an average of 1.6 types of different exercises with an average of at least 10 minutes per session. Those who were cognitively intact/mildly impaired were significantly more likely to be active than those who were impaired (55.0% vs. 29.5%, $p < 0.001$). The most frequently reported activities were walking (31.0%) and gardening/yard work (18.7%). Walkers reported walking an average of 4.7 times per week and gardeners (sessions of at least 20 minutes in length) reported an average of 2.6 times per week. Fifteen percent reported participating in one or more types of activities other than walking or gardening.

Table 4 presents the results from the linear regressions on the 1999 (5-year) MMSE scores and the change in the SPMSQ between 1994 and 2004. The analyses include those living in the community who tested intact or mildly impaired in 1994 and were tested in the later waves. The number of types of exercises pursued was associated with a higher MMSE score in 1999 and less increase in the number of errors on the SPMSQ between 1994 and 2004, both indicating a reduced risk of becoming impaired (Model 1). The effect was significant for the change between 1994 and 2004 ($p = 0.002$), but far from significant for the 1999 MMSE score ($p = 0.41$).

Model 2 shows the association with the number of periods of exercise of at least 20 minutes. The association was significant for the ten-year change ($p=0.007$), but only approached significance for the five-year MMSE ($p=0.093$). The number of sessions of 10-19 minutes was not associated with risk and was dropped from the analyses (results not shown). Model 3 shows that all types of exercise were associated with reduced risk of becoming impaired, although only the association between the number of sessions of gardening for the ten-year change was significant ($p=0.026$). For the five-year MMSE score, only gardening approached significance ($p=0.098$).

The data on gardening are actually “gardening or yard work.” To examine whether the effect of yard work might be different from the effect of gardening, we tested an interaction between the number of sessions of gardening and yard work with sex, assuming that women were more likely to garden and men were more likely to engage in yard work. There was no evidence that the effect of gardening and yard work differed by sex (results not shown).

We examined the reported prevalence in 1994 of medical conditions that would be expected to affect exercise that might also cause cognitive impairment. These conditions might bias the analysis if they reduced exercise participation in 1994, but did not cause moderate or severe cognitive impairment until a later stage of the disease. Including these individuals could only affect the analysis to the extent that they survive and did not enter an institution during the five or ten years of follow-up.

Among those judged intact or only mildly impaired in 1994 who survived until 1999, only 1.2% reported Parkinson’s disease and only 3.4% reported having had a stroke. Dropping these cases from the analysis did not change the results (results not shown). In the analysis we included controls for cases of diabetes and hypertension. These controls did not approach significance in any of the analyses. Adding a control for the presence of any of nine other conditions (multiple sclerosis, cerebral palsy, epilepsy, Parkinson’s disease, arteriosclerosis/hardening of the arteries, heart attack, any other heart problem, stroke, and circulation trouble in arms or legs) never approached significance and was removed from the analysis (results not shown).

Table 5 presents odds ratios showing the risks of various changes in living status associated with exercise in 1994. Living in the community without a caregiver is the reference group. The results for the three outcomes (living in community with caregiver, living in an institution and deceased) were all quite consistent with those in Table 4. The estimates suggest that exercising for 20 minutes or more was associated with a significant reduction in the odds for all three outcomes. For example, participating in a single type of activity (e.g., walking or gardening) during the past two weeks was associated with an odds ratio of becoming institutionalized during the next five years of 0.554 ($p<0.001$) relative to remaining in the community without a caregiver. Participating in two types of activities would be associated with an odds ratio of 0.554² or 0.307. However, all of the effect was due to the association with periods of exercise lasting 20 minutes or longer (Model 2). Again, periods of 10-19 minutes were not associated with risk and were dropped from the model (results not shown). Each session of 20 minutes or longer per week was associated with an odds ratio of becoming institutionalized during the next five years of 0.925 ($p=0.001$). For example, three sessions per week would be associated with an odds ratio of 0.925³ or 0.79. The effect was apparent for both walking (odds ratio for institutionalization: 0.921, $p=0.020$) and gardening/yard work (0.791, $p=0.003$) but not for other activities. Most of the results for the other outcomes (requiring a caregiver and dying) and for ten-year follow-up were similar.

4. Discussion

The results of this study add to the growing body of evidence in support of exercise as a potential intervention to decrease the risk of aging related cognitive impairment. Intriguingly, the strongest association was with the number of different types of activities pursued. This result is similar to the Cardiovascular Health Cognition Study finding that subjects who participated in at least four different physical activities over a two-week period decreased their risk of dementia when compared to those who engaged in one or less [30]. The strength of this association may be due to additive effects from socialization and cognitive stimulation. In other words, we speculate that those who pursued a greater variety of physical activities were more engaged, through their greater array of exercises, both cognitively and socially. Their diversity of physical activities may have connected them to more people and provided additional cognitive stimulation.

Our finding of a threshold effect – exercise sessions must be at least 20 minutes long – also concurs with previous studies. Larson et al. reported that in the Adult Changes in Thought (ACT) study subjects who exercised at least three times per week, ≥ 15 minutes per session, lowered their risk of dementia by 32% compared to those who exercised less [31] and Rovio et al. found that at least two exercise sessions per week, ≥ 20 minutes each, lowered the risk of dementia by 52% in the Cardiovascular risk factors, Aging and Incidence of Dementia (CAIDE) study [32].

We were somewhat surprised that results for cognitive impairment at the five-year follow-up did not reach significance, while results at the ten-year follow-up did. We attribute some of this discrepancy to the fact that the SPMSQ was utilized for baseline measurement, the MMSE was used for the five-year follow-up and the SPMSQ was again used for the ten-year follow-up. Switching to a different instrument to assess cognition may have led to misclassification of impairment status at the five-year follow-up, which was then rectified at the ten-year follow-up when the SPMSQ was again used. Perhaps a more important factor is that for unknown reasons, the MMSE was not administered to many subjects in 1999. It is possible that individuals who were very responsive to earlier parts of the interview and who appeared to be intact may have been less likely to be tested.

The associations between exercise and living status/level of independence followed similar patterns to those of cognitive impairment and, therefore, add compelling support to our findings. The number of different physical activities pursued was associated at follow-up, at both five and ten years, with a lower likelihood of each of the three outcomes (living in the community with a caregiver, institutionalized or deceased). Although we attribute a portion of these associations to the effects of exercise on health, we suggest that some might be due to additive benefits from socialization and cognitive stimulation. The threshold effect of exercise sessions that are at least 20 minutes long was also apparent at both follow-ups. When we analyzed the two most common forms of exercise, walking and gardening/yard work, their associations with living status at five-year follow-up were all significant, unlike our five-year follow-up results for cognitive impairment. We attribute this to our living status measures being more precise than relying on the MMSE as a definitive measure of cognitive impairment and the fact that there was much less missing information on living status.

Our study does have a number of limitations, most notably a lack of precision in measuring cognitive impairment and change in cognitive status using the MMSE and the SPMSQ. These instruments are designed to measure gross cognitive status and relying on them as outcome measures of change has well known limitations. Given that our results showed an association between exercise and cognitive impairment despite this limitation, we are persuaded that an association exists and with better outcome measures would in fact be more robust. Because we

were aware of the limitations of using the MMSE and SPMSQ as outcome measures, we also analyzed a global measure of functioning, living status or level of independence, in our analyses. The results using these measures are quite consistent with the results using cognitive impairment outcome measures. Although factors other than cognitive impairment impact living status, dementia is frequently the reason someone needs a caregiver or is institutionalized. In addition, although there are many reasons for institutionalization other than dementia, many of those other conditions are associated with very high mortality rates. Therefore, dementia patients constitute a relatively large proportion of individuals in institutions.

Relying on the SPMSQ to screen out subjects with dementia at baseline also was limiting because this may have resulted in our including individuals with cognitive impairment in our sample and possibly excluding subjects who in fact were not impaired. Both would affect our outcomes. We controlled for these problems by including the baseline score in the study of change between 1994 and 2004.

As is true with all association studies, there is some risk of reverse causation and joint causation. Reverse causation would only be a problem if very mild cognitive impairment not detected by the SPMSQ in a significant fraction of the sample reduced the amount of exercise appreciably. Reduced exercise caused by moderate or severe cognitive impairment detected by the baseline SPMSQ would not affect the results because those individuals are not included in the analysis. Individuals with mild cognitive impairment that affects exercise in 1994 would probably have a reduced chance of surviving and living outside an institution in 1999 and 2004 and, therefore, would be less likely to be included in the analysis. Our analysis suggests that joint causation (conditions that cause reduced exercise and cognitive impairment) is not driving the results. This is probably due to the low prevalence of the conditions that are most likely to have this effect (e.g., Parkinson's disease and stroke) and to the higher rates of mortality and institutionalization of individuals with these conditions at baseline.

Finally, given that the NLTCs did not collect data on exercise and cognitive status for members of the sample once they became institutionalized; our results are not generalizable to the entire U.S. population. However, the results can be generalized to the U.S. population of individuals not living in institutions who would score intact or mildly impaired on the SPMSQ in 1994.

These limitations notwithstanding, the results of this study using the NLTCs data to measure associations between exercise and cognitive impairment, as well as living status or level of independence, provide compelling evidence supporting the potential for exercise interventions to lower the risk of dementia.

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Figure 1.

Sample from baseline to five-year follow-up. The analysis of the MMSE score in 1999 was based on all those who received the MMSE. The analysis of living status and need for a caregiver were based on all of those whose status in 1999 was known.

Figure 2. Sample from baseline to ten-year follow-up. The analysis of changes in the SPMSQ was based on all those who received the SPMSQ in 2004. The analysis of living status and need for a caregiver were based on all of those whose status in 2004 was known.

Table 1

Baseline Characteristics by Cognitive Status, National Long Term Care Survey, 1994, Community Sample

	Total Sample (N=5,280 ^A)	Subjects with SPMSQ Scores in 1994 (N=4,382)	Subjects Who Were Cognitively Intact or Mildly Impaired in 1994 (N=3,863)
Age	N=5,263	N=4,370	N=3,853
65-69	14.1%	15.1%	16.5%
70-74	15.0%	15.6%	16.9%
75-79	31.6%	32.6%	33.7%
80-84	19.6%	19.6%	19.1%
85-89	11.4%	10.5%	9.1%
90-94	4.6%	4.0%	3.1%
95-99	3.5%	2.5%	1.6%
100+	0.2%	0.1%	0.1%
Education	N=4,996	N=4,262	N=3,863
≤ 9 th Grade	33.4%	31.9%	29.8%
> 9 th ≤ 12 th Grade	43.7%	43.9%	45.1%
At least Some College	23.0%	24.2%	25.1%
Marital Status	N=4,992	N=4,307	N=3,796
Female with spouse	19.8%	20.7%	22.1%
Male with spouse	24.5%	23.6%	23.8%
Unmarried	55.7%	55.7%	54.1%
Gender	N=5,276	N=4,379	N=3,860
Female	65.4%	66.4%	66.4%
Male	34.6%	33.6%	33.6%
Cognitive Function		N=4,382	
Intact		76.3%	
Mild impairment		11.9%	
Moderate impairment		4.0%	
Severe impairment		7.8%	

^A 31 subjects who reported (or proxy reported) AD, senility or mental retardation were excluded.

Table 2

Baseline Characteristics of Subjects Who Reported Exercising Compared to Those Who Did Not Report Exercising, National Long Term Care Survey, 1994

	Subjects Who Reported Exercising	Subjects Who Did Not Report Exercising
Age	N=2,498	N=2,235
65-69	18.1%	10.2%
70-74	17.6%	12.4%
75-79	33.6%	29.4%
80-84	17.5%	22.9%
85-89	8.5%	14.2%
90-94	3.0%	5.7%
95-99	1.7%	4.7%
100+	0.0%	0.5%
Education	N=2,462	N=2,171
≤ 9 th Grade	28.3%	39.0%
> 9 th ≤ 12 th Grade	42.7%	44.1%
At least Some College	28.9%	16.9%
Marital Status	N=2,467	N=2,198
Female with spouse	19.8%	20.1%
Male with spouse	31.7%	17.6%
Unmarried	48.5%	62.3%
Gender	N=2,503	N=2,241
Female	42.6%	26.1%
Male	57.4%	73.9%
Cognitive Function	N=2,279	N=1,868
Intact	83.8%	69.3%
Mild impairment	9.5%	14.6%
Moderate impairment	3.0%	5.2%
Severe impairment	3.7%	10.9%

Table 3

The Reported Prevalence of Various Types and Durations of Exercise by Level of Cognitive Impairment Indicated by the Number of Errors on the SPMSQ, National Long term Care Survey, 1994

	Total Sample (N=5,280)		Cognitively Intact/Mildly Impaired Subjects (N=3,863)		Cognitively Impaired (Moderate/Severe) Subjects (N=519)		Difference Between Intact/ Mildly Impaired and Impaired
	Percent Active	Mean for Active	Percent Active	Mean for Active	Percent Active	Mean for Active	P-values
Number of types of exercises performed	47.4%	1.6	55.0%	1.7	29.5%	1.3	.000
Exercise sessions of any type for:							
10 to < 20 min.	14.3%	4.9	15.9%	4.8	11.2%	4.9	.052
At least 20 min.	34.3%	5.4	41.3%	5.3	16.6%	5.4	.000
Walking for:							
10 to < 20 min.	9.0%	4.7	9.3%	4.6	9.6%	4.7	.744
At least 20 min.	22.0%	4.7	26.4%	4.7	11.4%	5.1	.000
Gardening or doing yard work for:							
10 to < 20 min.	1.7%	2.8	1.9%	2.8	0.8%	1.3	.049
At least 20 min.	17.0%	2.6	20.7%	2.5	6.9%	3.4	.000
Doing other activities for:							
10 to < 20 min.	5.0%	4.7	6.2%	4.6	1.3%	6.4	.002
At least 20 min.	10.0%	3.6	12.8%	3.7	2.5%	3.2	.000

Table 4

The Results of Linear Regressions Estimating the Effects of Various Measures of Exercise Reported in 1994 on the 1999 MMSE Scores and on the Change in the SPMSQ Between 1994 and 2004, National Long Term Care Survey

	MMSE in 1999 (Number of correct answers)		SPMSQ Change from 1994 to 2004 (Number of errors)	
	Coefficient	P-value	Coefficient	P-value
Model 1 :				
Number of types of exercises performed	0.134	0.410	-0.189	0.002
Model 2:				
Number of exercise sessions $\geq$ 20 minutes	0.074	0.093	-0.045	0.007
Model 3:				
Walking: $\geq$ 20 minutes	0.020	0.750	-0.041	0.081
Gardening: $\geq$ 20 minutes	0.176	0.098	-0.095	0.026
Other activities: $\geq$ 20 minutes	0.084	0.382	-0.001	0.977

Note: The sample sizes for 1999 are 1,203 for Model 1 and 1,240 for Models 2 and 3. For 2004 the sample sizes are 931 for Model 1 and 951 for Models 2 and 3. The analyses included controls for age, sex, education, relevant medical conditions (presence of diabetes or hypertension) and the baseline SPMSQ; analyses incorporated estimates of the reliability of the SPMSQ (0.82) and the reliability of the exercise measures (0.75).

Odds Ratios from Multinomial Logistic Regressions Associated with Various Measures of Exercise Reported in 1994 for the Risks of Needing a Caregiver, Becoming Institutionalized or Being Deceased by 1999 or 2004, National Long Term Care Survey

Table 5

Outcomes for 1999 (Coefficients with P-values in parentheses)						Outcomes for 2004 (Coefficients with P-values in parentheses)					
Community with Caregiver						Community with Caregiver					
Institution						Institution					
Deceased						Deceased					
Model 1:						Model 1:					
Number of types of exercises performed						Number of types of exercises performed					
0.647 (0.000)						0.645 (0.000)					
Model 2:						Model 2:					
Number of exercise sessions ≥ 20 minutes						Number of exercise sessions ≥ 20 minutes					
0.932 (0.000)						0.961 (0.013)					
Model 3:						Model 3:					
Walking: ≥ 20 minutes						Walking: ≥ 20 minutes					
0.935 (0.001)						0.927 (0.046)					
Gardening: ≥ 20 minutes						Gardening: ≥ 20 minutes					
0.898 (0.003)						0.934 (0.299)					
Other activities: ≥ 20 minutes						Other activities: ≥ 20 minutes					
0.953 (0.142)						0.984 (0.769)					

Notes: The sample sizes are 3,642 for Model 1 and 3,789 for Models 2 and 3. Living in community without a caregiver is the reference group for each alternative outcome. Each analysis included controls for age, sex, education and marital status.