Physical Activity and Functional Status in Community-Dwelling Older Women

A 14-Year Prospective Study

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Background: Short-term prospective studies have shown physical activity to be related to functional status. To our knowledge, the association between physical activity levels and functional status over a longer period has not been established.

Methods: Two hundred twenty-nine older women (mean age, 74.2 years) who were involved in a randomized controlled walking intervention from 1982 to 1985 were subsequently followed up until December 1999. Physical activity was assessed in 1985, 1995, and 1999 using a physical activity questionnaire and a physical activity monitor. In 1999, functional status was assessed by self-report and performance-based measures.

Results: Subjective and objective measures of physical activity in 1985 independently predicted gait speed in 1999 after controlling for age, chronic conditions, and activity limitation (subjective model-adjusted $R^2=0.09$ [P=.03]; and objective model-adjusted $R^2=0.13$ [P=.008]). The consistency of physical activity participation from 1985 to 1999 was also related to functional status in 1999. Women who were always active had the best functional status and women who were always inactive had the worst functional status. For difficulty with activities of daily living: those always active, 17 (37.8%) of 45 women; those inconsistently active, 24 (40.0%) of 60 women; and those always inactive, 39 (59.1%) of 66 women ($\chi^2$ for trend $P=.02$). For score on the Physical Performance Test: those always active, 24.9; those inconsistently active, 24.5; and those always inactive, 23.8 (analysis of variance with linear contrasts $P=.04$). For gait speed: those always active, 1.17 m/s; those inconsistently active, 1.15 m/s; and those always inactive, 1.03 m/s (analysis of variance with linear contrasts $P=.002$).

Conclusion: We demonstrated a significant relation between physical activity during a 14-year period and current functional status in older women, thus suggesting that physical activity plays a role in maintaining functional ability later in life.

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RECENTLY, the focus of aging research has switched from mortality and longevity to health status and quality of life.1 No longer is it only important that one lives longer, but the quality of life in the later years must also be considered. A key component of health-related quality of life is the ability to take care of oneself and function independently.2

Physical activity and functional status are related in community-dwelling older adults, with individuals who are more active having fewer functional limitations than inactive individuals.3-8 Prospective studies3-8 in community-dwelling older adults have linked low levels of physical activity at baseline to decreased functional status several years later. However, these studies relied primarily on self-report measures of functional status, which provide information regarding persons’ perception of their ability to complete a task and may not accurately capture individuals’ ability to actually perform. The few studies9,10 that included performance-based measures of functional status had a short follow-up period (2½-5 years).

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This prospective study examines the long-term association of physical activity to functional status in a sample of community-dwelling older women (mean age, 74.2 years). We will describe the association between physical activity levels during a 14-year period (1985-1999) and current functional status (1999) using self-report and performance-based measures of physical activity and functional status.
A randomized controlled trial to examine the effects of walking on measures of bone in postmenopausal women was conducted from 1982 to 1985, with follow-ups in 1995 and 1999. Volunteer women who met the following 4 baseline criteria were eligible: (1) aged 50 to 65 years, (2) at least 1 year after cessation of menopause, (3) absence of estrogen therapy, and (4) no physical limitations that might preclude walking. The randomized controlled trial was conducted in Pittsburgh and the surrounding area, which can be considered an urban/suburban community. Two hundred twenty-nine middle-class women were assigned at random to either a walking intervention or a control group. The goal of the intervention program was for each woman to achieve and maintain a minimum walking distance of 11.2 km/wk (7 miles/wk). The women could walk on their own or with one of the walking groups that was organized by the study and conducted by one of the study's exercise leaders (A.M.K.). At the end of the trial, women in the walking group had significantly (P range, .006 to .03) higher levels of physical activity on subjective and objective measures of physical activity. In 1995, a follow-up telephone interview was administered to the cohort of women to determine physical activity levels and health status a decade later. In 1999, the surviving women from the original clinical trial (1982-1985) were asked to return to the clinic for a comprehensive examination, including measures of heart disease, bone density, body composition, physical activity levels, health status, and functional status. Of the original 229 women, 171 completed the clinic visit, 17 participated in telephone interviews only (14 had complete and 3 had incomplete telephone interviews), 20 were deceased, 8 were too sick to participate, 10 were lost to follow-up, and 3 refused to participate. Therefore, self-report or questionnaire data were potentially available for 188 women, and performance-based data were potentially available for 171 women. Of the 171 women who attended the clinic visit, 8 did not return the pedometer diary and 1 did not have complete gait speed data. This research was approved by the University of Pittsburgh Institutional Review Board, and informed consent was obtained from all participants before their participation in the study.

PHYSICAL ACTIVITY

Physical activity levels have been measured at 3 points (1985, 1995, and 1999) since the end of the randomized controlled trial. Self-reported physical activity was measured using a modified version of the Paffenbarger questionnaire at all of these points. In 1985, the physical activity questionnaire included items that measured physical activity during sport/leisure activities, stair climbing, and blocks walked during the past week. In 1995 and 1999, the physical activity questionnaire included only sport/leisure activities and walking for exercise. In 1995 and 1999, total activity was calculated for the week averaged over the past year. To ensure that the measures of physical activity from the questionnaires were comparable across the 3 points, physical activity from stair climbing was subtracted from the 1985 physical activity measure.

Objective measures of physical activity were obtained using a large-scale integrated (LSI) monitor in 1985 and a pedometer (Yamax Digi-Walker) in 1999. At the end of the randomized controlled trial (1985), physical activity was measured using an LSI activity monitor worn on the hip. The LSI activity was expressed as counts per hour, based on a 3° inclination or declination of the monitor from the upright position, which produces closure of a mercury switch that was then registered on an internal counter. The participant wore the LSI monitor for 1 week and recorded daily in a diary the number of counts and the number of hours the monitor was worn. The activity counts recorded in the diary from the monitor were averaged for the week. In 1999, physical activity was measured objectively using a pedometer. Participants wore the pedometer clipped to the waistband over their dominant hip for 1 week, and documented on a weekly activity log the number of steps recorded by the pedometer. A 7-day average of the number of steps taken per day was calculated from the activity log. A pedometer records the number of steps taken; it does not provide a measure of activity counts as does the LSI monitor.

FUNCTIONAL STATUS

In 1999, functional status was measured using self-report and performance-based measures. The Functional Status Questionnaire (FSQ) was used as the self-report measure of function. The questions on the FSQ inquire about the amount of difficulty a person has had completing a task during the past month. The 2 activities of daily living (ADL) sections of the FSQ, basic and instrumental ADLs, were selected for examination. The basic ADL section includes questions about difficulty with eating, dressing, bathing, and mobility tasks. The instrumental ADL section includes questions about difficulty walking several blocks, climbing stairs, doing housework, shopping, using public transportation, and doing vigorous activities. The basic and instrumental ADL sections of the FSQ were used to classify the women as having no ADL difficulty (ie, reporting no difficulty on all of the basic and instrumental ADL items) or any ADL difficulty (ie, reporting difficulty on at least 1 of the basic or instrumental ADL items).

The 7-item Physical Performance Test (PPT) and gait speed were used as performance-based measures of function. The 7-item PPT is a comprehensive performance-based measure of physical performance of typical daily activities. It consists of the following tasks: writing a sentence, simulated eating, lifting a book to a shelf, putting on a jacket, picking up a penny, turning 360°, and walking. The 7-item PPT was administered and scored following the protocol described by Reuben and colleagues. Scores on the 7-item PPT range from 0 to 28, with lower scores indicating poorer performance.

Gait speed was measured using an instrumented walkway (GaitMat II analysis system). This is an automated gait analysis system based on the opening and closing of pressure-sensitive switches when the participant walks on a 4-m-long walkway. In addition to the 4-m-long walkway, there are initial and final 1-m sections to allow for acceleration and deceleration of the participant. Gait speed was determined by dividing the distance traversed in meters by the time in seconds between the first and last switch closure.

DATA ANALYSIS

The association between physical activity and functional status was examined using Spearman rank order correlation coefficients. To further examine the association of past physical activity (physical activity in 1985 and 1995) to current functional status (functional status in 1999), the women were divided into more active and less active groups using 2 different methods. First, using the physical activity reported on the questionnaire, the women were classified based on whether they met the surgeon general’s recommended level of physical activity (physical activity in 1985 and 1995) to current functional status (functional status in 1999), the women were divided into more active and less active groups using 2 different methods. First, using the physical activity reported on the questionnaire, the women were classified based on whether they met the surgeon general’s recommended level of physical activity (30 minutes of moderate physical activity on most days of the week), which is crudely comparable with expending 1000 kcal/wk. Second, the women were classified as more or less active using the median split of the LSI monitor counts.
Current functional status was also examined in relation to the consistency of physical activity participation from the end of the intervention trial (1985) to 1995. The participants were classified as never active, reporting fewer than 1000 kcal/wk of physical activity in 1985 and 1995; always active, reporting 1000 kcal/wk or more of physical activity in 1985 and 1995; or inconsistently active, reporting 1000 kcal/wk or more of physical activity in either 1985 or 1995. Functional status measures from 1999 were compared across the 3 groups (never active, inconsistently active, and always active) using the $\chi^2$ test for trend for categorical data and a 1-way analysis of variance with linear contrasts (ie, test for trend) for continuous data.24

Multivariate linear regression models were constructed to examine the association between past physical activity and current functional status (gait speed in 1999). The consistency of physical activity (never active, inconsistently active, or always active) was used as the measure of past physical activity. In the models, we controlled for age, self-reported number of chronic conditions in 1999, and self-report of physical activity limited by health (yes or no) in 1999. All 2-way interactions with physical activity were examined. Data analysis was conducted using SAS statistical software, version 8.1 (SAS Institute Inc, Cary, NC).

## RESULTS

The mean (SD) age of the women participating in the 1999 study was 74.2 (4.3) years. In general, the participants were relatively healthy active women, with few limitations in functional status (Table 1). This was evident by the fact that most of the women reported on the FSQ in 1999 that they had no difficulty with basic ADL (77.1%) or instrumental ADL (60.0%).

### Performance based

- Use assistive device 188 20 (10.6)
- Satisfied with health 187 152 (81.3)
- Any ADL difficulty 185 74 (40.0)
- Gait speed, m/s 170 1.11 (0.22)
- Performance based

### Self-report

- Basic ADL difficulty 188 43 (22.9)
- Any ADL difficulty 185 85 (45.9)
- Monitor, steps/d 163 5115.6 (3243.6-7021.4)
- Instrumental ADL difficulty 185 74 (40.0)
- Physical activity limited by health
- Monitor 135 23 (12.2)
- Questionnaire 188 1038.5 (415.4-2273.1)

**Abbreviations:** ADL, activities of daily living; PPT, Physical Performance Test.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total No. of Participants</th>
<th>Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>177</td>
<td>74.2 (4.3)†</td>
</tr>
<tr>
<td>Body mass index‡</td>
<td>171</td>
<td>27.2 (5.5)†</td>
</tr>
<tr>
<td>Health status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfied with health</td>
<td>187</td>
<td>152 (81.3)</td>
</tr>
<tr>
<td>Use assistive device</td>
<td>188</td>
<td>20 (10.6)</td>
</tr>
<tr>
<td>Physical activity limited by health</td>
<td>188</td>
<td>23 (12.2)</td>
</tr>
<tr>
<td>Functional status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic ADL difficulty</td>
<td>188</td>
<td>43 (22.9)</td>
</tr>
<tr>
<td>Instrumental ADL difficulty</td>
<td>185</td>
<td>74 (40.0)</td>
</tr>
<tr>
<td>Any ADL difficulty</td>
<td>185</td>
<td>85 (45.9)</td>
</tr>
<tr>
<td>PPT score</td>
<td>171</td>
<td>24.3 (2.8)†</td>
</tr>
<tr>
<td>Gait speed, m/s</td>
<td>170</td>
<td>1.11 (0.22)†</td>
</tr>
</tbody>
</table>

$^*$Data are given as number (percentage) of participants unless otherwise indicated. Percentages are based on the total number of participants for that characteristic.

$\dagger$Data are given as mean (SD).

$\ddagger$Calculated as weight in kilograms divided by the square of height in meters.

$\S$Data are given as median (25th-75th percentile).

$\|$The range of possible scores is from 0 to 28.

**Table 1. Characteristics of Study Participants in 1999**

The performance-based measures of function, the PPT score and gait speed, were more strongly related to the performance-based measures of physical activity (pedometer/monitor) than the self-report measure of function.

Compared with the less active women in 1995, the more active women in 1995 reported fewer difficulties with ADL, performed better on the PPT, and walked faster in 1999 (Table 3). Likewise, when comparing the less active with the more active women based on the LSI monitor classifications from 1985, the more active women in 1985 were less likely to have functional limitations in 1999 (Table 3). However, when the women were classified as less active and more active using self-reported physical activity from 1985, there were no differences in functional status in 1999 between the 2 groups (Table 3). After controlling for age, chronic conditions, and activity limitation, physical activity in 1985 as measured by the physical activity questionnaire or by the LSI movement monitor was a significant independent predictor of gait speed in 1999 (questionnaire: $\beta=.003$, $P=.03$, and model-adjusted $R^2=.09$; and monitor: $\beta=.028$, $P=.008$, and model-adjusted $R^2=.13$). Likewise, physical activity as measured by the questionnaire in 1995 was also a significant independent predictor of gait speed in 1999 ($\beta=.004$, $P<.001$, and model-adjusted $R^2=.19$).

**CONSISTENCY OF PAST PHYSICAL ACTIVITY AND CURRENT FUNCTIONAL STATUS**

To examine the association between consistent past physical activity and current functional status, we used the ac-
activity groupings based on the recommended level of physical activity from the physical activity questionnaire (never active [reporting <1000 kcal/wk of physical activity in 1985 and 1995], inconsistently active [reporting ≥1000 kcal/wk of physical activity in 1985 or 1995], or always active [reporting ≥1000 kcal/wk of physical activity in 1985 and 1995]). We had complete physical activity data from the 1985 and 1995 questionnaires for 171 participants. Of the 171 participants, 45 (26.3%) reported at least 1000 kcal/wk of physical activity at both time points. We classified these participants as being always active. Of the participants, 66 (38.6%) reported less than 1000 kcal/wk of physical activity at both time points. We classified these participants as being always inactive. The remaining women, 60 (35.1%), were classified as being inconsistently active from 1985 to 1995.

The \( \chi^2 \) test for trend and the 1-way analysis of variance with linear contrasts (ie, test for trend) showed that the more bouts of recommended physical activity level from 1985 to 1995 (ie, consistency of physical activity) that the women participated in, the better their functional status was in 1999 (Figure). Only 17 (37.8%) of the 45 women who were above the recommended level of physical activity at both time points (ie, always active) reported difficulty with ADL in 1999, compared with 24 (40%) of the 60 women who inconsistently met the recommended level of physical activity (ie, inconsistently active) and 39 (59.1%) of the 66 women who were always below the recommended level of physical activity (ie, always inactive) \((P=0.02)\). Likewise, women who were above the recommended level of physical activity in 1985 and 1995 had a faster gait speed in 1999 compared with women who were below the recommended level of physical activity in 1985 or 1995 or below the recommended level of physical activity in both years \((1.17 \text{ vs } 1.15 \text{ vs } 1.03 \text{ m/s}; P=0.002)\). Eliminating women who reported in 1999 that their physical activity was limited by their health from the analyses, the association between past physical activity and current functional status was weakened but remained significant \((data \ not \ shown)\).

Consistency of physical activity (ie, being never active, inconsistently active, or always active) was a significant \((P=0.006)\) predictor of gait speed in 1999 \((Table 4)\). After controlling for age, number of chronic conditions present in 1999, and if physical activity was limited by health in 1999, consistency of past physical activity contributed to the prediction of gait speed in 1999 \((B=0.08; P<0.001$, and model-adjusted \(R^2=0.14)\). Not surprisingly, when we eliminated those women who reported in 1999 that their physical activity was limited by their health, the association between past physical activity and gait speed in 1999 remained \((data \ not \ shown)\). All 2-way interactions with physical activity were not significant predictors of gait speed \((P \text{ range, } 0.25 \text{ to } 0.52)\).

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**Table 2. Relation of Physical Activity From 1985 to 1999 to Functional Status in 1999 by Spearman Rank Order Correlations**

<table>
<thead>
<tr>
<th>Physical Activity Measure</th>
<th>Functional Status Questionnaire</th>
<th>Physical Performance Test</th>
<th>Gait Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured in 1985</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity monitor</td>
<td>0.13 (n = 140)</td>
<td>0.15 (n = 131)</td>
<td>0.22* (n = 130)</td>
</tr>
<tr>
<td>Modified Paffenbarger questionnaire</td>
<td>0.03 (n = 179)</td>
<td>0.03 (n = 167)</td>
<td>0.10 (n = 166)</td>
</tr>
<tr>
<td>Measured in 1995</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified Paffenbarger questionnaire</td>
<td>0.23* (n = 176)</td>
<td>0.11 (n = 163)</td>
<td>0.37* (n = 162)</td>
</tr>
<tr>
<td>Measured in 1999</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedometer</td>
<td>0.34* (n = 163)</td>
<td>0.41* (n = 165)</td>
<td>0.52* (n = 164)</td>
</tr>
<tr>
<td>Modified Paffenbarger questionnaire</td>
<td>0.34* (n = 185)</td>
<td>0.16† (n = 171)</td>
<td>0.24* (n = 170)</td>
</tr>
</tbody>
</table>

\*\(P<.01\).
†\(P<.05\).

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**Table 3. Description of Functional Status in 1999 by Physical Activity Level in 1985 and 1995**

<table>
<thead>
<tr>
<th>1999 Functional Status</th>
<th>1985 Physical Activity Measures</th>
<th>1995 Physical Activity Measure (Questionnaire)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any activities of daily living difficulty, %</td>
<td>Less Active (n = 104)</td>
<td>More Active (n = 75)</td>
</tr>
<tr>
<td>Physical Performance Test score, mean (SD)</td>
<td>24.2 (3.2) (n = 99)</td>
<td>24.4 (2.3) (n = 68)</td>
</tr>
<tr>
<td>Gait speed, mean (SD), m/s</td>
<td>1.10 (0.23) (n = 98)</td>
<td>1.13 (0.21) (n = 68)</td>
</tr>
</tbody>
</table>

*Less active indicates those reporting less than 1000 kcal/wk of physical activity on the modified Paffenbarger questionnaire; and more active, those reporting 1000 kcal/wk or more of physical activity on the modified Paffenbarger questionnaire.
†Less active is less than the median value of the physical activity monitor; and more active, the median value or higher of the physical activity monitor.
‡\(P<.05\).
§\(P<.01\).
Performance Test (PPT) score (analysis of variance with linear contrasts thus suggesting the importance of physical activity in functional status 14 years later in postmenopausal women. Physical activity seems to be related to functional status over a long period. The ability to detect an association between physical activity and functional status is most likely attributed to our measurement techniques.

Throughout our study, we were able to show that physical activity was related to functional status. Similar to other researchers, we demonstrated that over a short period, physical activity was related to functional status. However, unlike other investigators, we demonstrated that physical activity at baseline and functional status included longer follow-up periods. For example, Simonsick et al examined the association between physical activity at baseline and functional status in 3 and 6 years later. At the first follow-up (3 years), physical activity was related to functional status. However, with increased time between the physical activity and functional status measures (6 years), the association was significantly weakened. Likewise, in an extensive 21-year prospective study, physical activity at baseline was not associated with functional status at the end of the study.

This study is one of the first to examine the long-term effects of physical activity on functional status in older women. Physical activity seems to be related to functional status 14 years later in postmenopausal women, thus suggesting the importance of physical activity in maintaining functional ability later in life. Our findings were consistent whether we used gait speed, the PPT score, or self-reported ADL function as the outcome, thus strengthening our findings.

While several prospective studies have demonstrated that physical activity is related to functional status, a few have failed to show a similar association. Most studies that have shown an association between physical activity and functional status have had a short follow-up period, usually less than 6 years. The studies that failed to show an association between physical activity and functional status included longer follow-up periods. For example, Simonsick et al examined the association between physical activity at baseline and functional status 3 and 6 years later. At the first follow-up (3 years), physical activity was related to functional status. However, with increased time between the physical activity and functional status measures (6 years), the association was significantly weakened. Likewise, in an extensive 21-year prospective study, physical activity at baseline was not associated with functional status at the end of the study.

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Throughout our study, we were able to show that physical activity was related to functional status. Similar to other researchers, we demonstrated that over a short period, physical activity was related to functional status. However, unlike other investigators, in our study the association between physical activity and functional status was maintained over a longer period. The ability to detect an association between physical activity and functional status over a long period is most likely attributed to our measurement techniques.

Several prospective studies have examined the association between physical activity and functional status using a self-report measure of function. Our research is unique in that self-report and performance-based measures of functional status were used as outcome measures. Although relatively easy and inexpensive to administer, self-report measures of function are limited in that they may be influenced by a predisposed view of the respondent. Performance-based measures of function are less likely to be influenced by affective, social, economic, and cognitive factors. By including performance-based measures of function, we were more likely to identify slight declines of function in this cohort of women.
healthy older adults with few limitations in functional status. The long-term follow-up and high participant retention are 2 major strengths of this investigation. We were able to determine the vital status of 219 of the participants (95.6% of the original sample), and we had complete functional status measures for approximately 74.7% of the original sample. However, the shrinkage of our sample does somewhat limit our conclusions. Several studies have examined the short-term association between physical activity and functional status, with the follow-up not exceeding 6 years. However, this research is unique in that the women were followed up for an extended period (14 years).

The effects of physical activity on functional status may be short term, and to best reap the benefits in functional status, an individual may need to continue to be physically active over a lifetime. By examining the association between being always active, always inactive, or inconsistently active over an extended period (1985-1995) and current functional status (1999), we began to address this hypothesis. We discovered a dose-response relationship, with women who were always active (ie, high dose of activity) having a better functional status than women who were inconsistently active (ie, medium dose of activity), who had a better functional status than women who were never active (ie, low dose of activity). One possible explanation of these findings is that consistent activity over time is better than inconsistent activity or no activity over time for future functional status.

One limitation is the relatively homogeneous sample of women. Most of the participants were of upper social economic status and white, as determined at the initiation of the randomized trial in 1982. The homogeneous nature of our sample does limit the generalizability of our findings. However, the similarity of the participants could also be possibly viewed as a strong point, in that the number of potential confounding factors, such as race or social economic status, was reduced.

The outcome of interest, functional status, was not measured during the original clinical trial (1982-1985). It is reasonable to assume that the women were free of functional limitations at the start of the trial, because to participate the women had to report that they did not have limitations that would preclude them from exercising. However, it would have been beneficial to have measured functional status at the initiation of the trial to confirm this assumption.

During the study, the measures of physical activity changed slightly. However, attempts were made to keep the measures as similar as possible. For example, because stair climbing was not included in the recent physical activity questionnaire, physical activity from stair-climbing activity was deleted from the earlier physical activity questionnaires. However, we did not use absolute physical activity values in our analyses, but instead compared the ranking of these measures (ie, relative values [more or less active]).

We demonstrate the importance of an active lifestyle to functional status in older upper socioeconomic class white women. We have shown, in a relatively healthy sample, the importance of physical activity in maintaining physical function. There is a need for similar research to be conducted in a more diverse group of individuals, including individuals from racial minority groups, individuals of lower socioeconomic status, and individuals with deficits in functional status. To our knowledge, individuals with deficits in functional status have typically not been the focus of studies examining the benefits of physical activity on health and functional status.

With people living longer, it is important to prevent the decline in functional status that occurs with age. Getting individuals to maintain adequate levels of physical activity across the lifespan could prevent declines in physical function, which would have major public health significance. Not only could sustained physical activity improve health-related quality of life for older adults, it may also decrease health care expenditures related to the care of individuals with deficits in functional status.

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REFERENCES


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