| 論文名 | Leisure time physical activity in relation to depressive symptoms in the Black Women's Health Study. |
|---|---|
| 著　者 | Wise LA, Adams-Campbell LL, Palmer JR, Rosenberg L. |
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| 対象の内訳 | | ヒト | 動物 | 地　域 | 欧米 | 研究の種類 | 縦断研究 |
|---|---|---|---|---|---|---|---|
| | 対象 | 一般健常者 | 空白 | | ( USA ) | | コホート研究 |
| | 性別 | 女性 | (　　) | | (　　) | | (　　) |
| | 年齢 | 21-69 | [redacted] | | (　　) | | 前向きコホート |
| | 対象数 | 10000以上 | | | (　　) | | (　　) |
| 調査の方法 | 実測 | (　　) | | | | | |
| アウトカム | 予　防 | なし | なし | なし | なし | | (　　) |
| | 維持・改善 | な し | な し | な し | 心理的指標改善 | (　　) | (　　) |

図　表

**TABLE 3**
Multivariate Odds Ratios (ORs) for Depressive Symptoms in 1999 (CES–D 16+) in Relation to Leisure Time Physical Activity, Stratified by Age and Body Mass Index (BMI) at Baseline

| Type of Physical Activity | Younger Than Age 40: No. | CES–D ≥ 16 (%) | Multivariate OR (95% CI)[a] | Age 40 or Older: No. | CES–D ≥ 16 (%) | Multivariate OR (95% CI)[a] |
|---|---|---|---|---|---|---|
| Adult vigorous activity, hr/week | | | | | | |
| None | 3,522 | 37.3 | 1.00[b] | 4,915 | 23.8 | 1.00[b] |
| < 2 | 8,902 | 31.3 | 0.84 (0.77–0.91) | 5,850 | 21.9 | 0.89 (0.81–0.98) |
| 2–4 | 5,799 | 26.1 | 0.70 (0.63–0.77) | 2,668 | 18.2 | 0.75 (0.66–0.85) |
| 5+ | 2,458 | 28.5 | 0.77 (0.68–0.88) | 1,110 | 19.6 | 0.78 (0.65–0.93) |
| Test for continuous trend[c] | | | $p = .017$ | | | $p = .004$ |
| Adult walking for exercise, hr/week | | | | | | |
| None | 2,120 | 32.4 | 1.00[b] | 1,272 | 25.6 | 1.00[b] |
| < 2 | 10,282 | 31.4 | 1.08 (0.97–1.20) | 6,832 | 23.1 | 0.99 (0.86–1.14) |
| 2–4 | 6,187 | 28.5 | 1.01 (0.90–1.14) | 4,652 | 18.8 | 0.85 (0.73–1.00) |
| 5+ | 2,092 | 30.5 | 1.05 (0.91–1.21) | 1,787 | 21.0 | 0.98 (0.82–1.18) |
| Test for continuous trend[c] | | | $p = .41$ | | | $p = .20$ |
| Lifetime vigorous activity, hr/week | | | | | | |
| Never active | 8,455 | 33.2 | 1.00[b] | 7,082 | 23.3 | 1.00[b] |
| Active in high school, inactive in adulthood | 5,037 | 31.1 | 0.93 (0.87–1.01) | 3,725 | 21.0 | 0.86 (0.78–0.95) |
| Inactive in high school, active in adulthood | 2,569 | 27.4 | 0.85 (0.77–0.94) | 1,271 | 19.0 | 0.79 (0.67–0.92) |
| Always active | 4,138 | 26.0 | 0.77 (0.71–0.84) | 1,659 | 18.6 | 0.75 (0.65–0.86) |
| | BMI < 30: No. | CES–D ≥ 16 (%) | Multivariate OR (95% CI)[a] | BMI 30+: No. | CES–D ≥ 16 (%) | Multivariate OR (95% CI)[a] |
| Adult vigorous activity, hr/week | | | | | | |
| None | 5,077 | 27.0 | 1.00[b] | 3,360 | 33.1 | 1.00[b] |
| < 2 | 10,292 | 25.8 | 0.88 (0.81–0.96) | 4,460 | 31.6 | 0.85 (0.76–0.94) |
| 2–4 | 6,743 | 22.8 | 0.75 (0.68–0.82) | 1,724 | 26.7 | 0.68 (0.59–0.78) |
| 5+ | 2,971 | 24.5 | 0.78 (0.69–0.87) | 597 | 31.8 | 0.86 (0.70–1.06) |
| Test for continuous trend[c] | | | $p < .001$ | | | $p = .19$ |
| Adult walking for exercise, hr/week | | | | | | |
| None | 2,364 | 27.8 | 1.00[b] | 1,028 | 34.4 | 1.00[b] |
| < 2 | 11,843 | 25.9 | 1.01 (0.91–1.12) | 5,271 | 32.9 | 1.10 (0.94–1.27) |
| 2–4 | 7,981 | 23.1 | 0.95 (0.85–1.06) | 2,858 | 27.9 | 0.94 (0.79–1.10) |
| 5+ | 2,895 | 25.1 | 1.05 (0.92–1.20) | 984 | 39.2 | 0.93 (0.76–1.15) |
| Test for continuous trend[c] | | | $p = .94$ | | | $p = .007$ |
| Lifetime vigorous activity, hr/week[d] | | | | | | |
| Never active | 10,394 | 26.3 | 1.00[b] | 5,143 | 33.6 | 1.00[b] |
| Active in high school, inactive in adulthood | 5,959 | 25.6 | 0.95 (0.88–1.02) | 2,803 | 29.3 | 0.83 (0.75–0.92) |
| Inactive in high school, active in adulthood | 3,125 | 24.0 | 0.88 (0.80–0.97) | 715 | 27.3 | 0.71 (0.59–0.85) |
| Always active | 4,716 | 22.8 | 0.78 (0.72–0.85) | 1,081 | 28.6 | 0.73 (0.63–0.85) |

*Note.* CES–D = Center for Epidemiologic Studies–Depression Scale; CI = confidence interval.

[a]Adjusted for age, education, occupation, marital status, preexisting health conditions, energy intake, smoking, current alcohol consumption, and child care responsibilities. Mutually adjusted for each form of physical activity.

[b]Reference group.

[c]Excludes zero-level exposure category.

[d]Active = 5+ hr in high school or 2+ hr in adulthood.

| 図表掲載箇所 | |
|---|---|
| 概　要<br>(800字まで) | ＜目的＞幾つかのエビデンスにより、身体活動が抑うつ症状のリスクを減らすことを示唆しているが、黒人女性のデータは不十分である。本研究の目的は、米国の黒人女性の余暇身体活動と抑うつ症状との関連性を評価することであった。＜方法＞参加者は35224人の、21歳から69歳の黒人女性であった。参加女性は、ベースライン時に過去と現在の身体活動レベルの質問に答えて(1995年)、1997年以降フォローアップに回答した。調査は郵送アンケートによって実施、回収された。疫学的研究抑うつ尺度(CES-D)は、1999年から抑うつ症状を測定するために使用されているため、1999年以前にうつ病の診断を報告した女性は研究の対象から除外した。抑うつ症状(CES-Dスコア16点以上)の発症に対する身体活動水準の違いによるオッズ比(OR)と95%信頼区間(CI)を計算の際に、潜在的な交絡因子を調整するために多変量ロジスティック回帰モデルを使用した。＜結果＞現在活発な身体活動を行なっている女性は低い抑うつ症状発症リスクを有していた。高等学校の頃に5時間週以上あるいは現在の成人期に2時間／週以上の両方で活発な運動を報告した女性は高校から成人まで不活発だった女性と比較して、抑うつ症状の最も低い相対オッズ(OR = 0.76、95%= 0.71から0.82 CI)を示した。高校時代に不活動であったが、成人期に活動的になった女性のオッズは0.83、高校で活動的だったが成人で不活動な女性は0.90だった。運動として歩くことは、全体的には抑うつ症状リスクと関連していなかったが、肥満の女性(BMI 30以上)においてのみ弱い逆相関があった。 |
| 結　論<br>(200字まで) | 余暇時間の活発な身体活動は、米国の黒人女性における抑うつ症状の減少と関連していた。 |
| エキスパートによるコメント<br>(200字まで) | 黒人女性のうつなどの精神疾患の予防には活発な余暇身体活動が重要であることを示唆した貴重な研究。 |

担当者　　宮地元彦

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循環器疾患・糖尿病等生活習慣病対策総合研究事業

# 健康づくりのための運動基準・運動指針改定ならびに普及・啓発に関する研究

（H２２−循環器（生習）−指定−０２１）

平成２４年度　総括・分担研究報告書（別冊）

研究代表者　宮地　元彦

平成２５年（2013）年３月

下 巻

# ３．65 歳以上における身体活動量の基準値策定に用いた文献

15 July 1998 Volume 129 Number 2

**Annals of Internal Medicine**

# Physical Activity and Osteoporotic Fracture Risk in Older Women

Edward W. Gregg, PhD; Jane A. Cauley, DrPH; Dana G. Seeley, PhD; Kristine E. Ensrud, MD, MPH; and Douglas C. Bauer, MD, for the Study of Osteoporotic Fractures Research Group*

**Background:** Physical activity has been related to enhanced bone mass and improved physical functioning and thus may reduce the risk for osteoporotic fracture.

**Objective:** To determine whether higher levels of physical activity are related to lower incidence of hip, wrist, and vertebral fractures.

**Design:** Prospective cohort study.

**Setting:** Four clinical centers in Baltimore, Maryland; Portland, Oregon; Minneapolis, Minnesota; and the Monongahela Valley, Pennsylvania.

**Participants:** 9704 nonblack women 65 years of age or older.

**Measurements:** Physical activity was assessed by questionnaire at baseline. Hip and wrist fractures were followed for an average of 7.6 years. The incidence of vertebral fracture was determined morphometrically by using radiography at baseline and an average of 3.7 years later.

**Results:** Higher levels of leisure time, sport activity, and household chores and fewer hours of sitting daily were associated with a significantly reduced relative risk for hip fracture after adjustment for age, dietary factors, falls at baseline, and functional and health status. Very active women (fourth and fifth quintiles) had a statistically significant 36% reduction in hip fractures (relative risk, 0.64 [95% CI, 0.45 to 0.89]) compared with the least active women (lowest quintile). The intensity of physical activity was also related to fracture risk: Moderately to vigorously active women had statistically significant reductions of 42% and 33% in risk for hip and vertebral fractures, respectively, compared with inactive women. Total physical activity, hours of household chores per day, and hours of sitting per day were not significantly associated with wrist or vertebral fractures.

**Conclusions:** Among older community-dwelling women, physical activity is associated with a reduced risk for hip fracture but not wrist or vertebral fracture.

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An estimated 6 million to 9 million women in the United States have osteoporosis, and approximately 1.3 million women each year have fractures (1-3). For 16% of women, the most severe outcome is hip fracture, which is often followed by an array of comorbid conditions and is a precursor of death within 6 months in 12% to 40% of cases (3-6). Prevention of osteoporotic fractures is thought to hinge on the ability to reduce bone loss and risk for falling in older women (6-10). Physical activity has been associated with enhanced bone mass or reduced bone loss and may reduce the risk for falling in older women by improving muscle strength, balance, mobility, and overall physical function (11-17). This combination of effects raises the question of whether physical activity prevents osteoporotic fractures.

Epidemiologic studies of the relation between physical activity and risk for osteoporotic fracture have been suggestive but inconclusive. Case-control studies have shown that persons with fractures are more likely to report having been inactive recently and earlier in their lives (18-23). In a prospective study (24), Paganini-Hill and colleagues found that women and men who were active for at least 1 hour daily had a 38% and 49% reduced risk for hip fracture, respectively, compared with their less active peers. Other prospective studies with lower statistical power have suggested that physical activity protects against hip fracture but have not found these relations to be statistically significant in multivariate analyses (25, 26). In an earlier examination of the risk factors for hip fracture among women in the Study of Osteoporotic Fractures, Cummings and colleagues (10) found that women who reported walking for exercise had a statistically significant 30% reduction in risk for hip fracture compared with women who did not walk for exercise.

**See editorial comment on pp 133-134.**

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We expanded our analysis of the Study of Osteoporotic Fractures cohort to examine the relation of several domains of physical activity to the risk for osteoporotic fractures. To determine the association of types, amounts, and intensity of physical activity with risk for fracture in older women, we measured baseline levels of physical activity and inactivity in 9704 women 65 years of age and older who were enrolled in the Study of Osteoporotic Fractures and followed them for incident hip, wrist, and vertebral fractures.

## Methods

### Patients

The study population consisted of 9704 nonblack women 65 years of age and older who were participating in the Study of Osteoporotic Fractures (9). Participants were recruited from population-based lists (health maintenance organizations, voter registration, and motor vehicle tapes) in Baltimore, Maryland; Minneapolis, Minnesota; Portland, Oregon; and the Monongahela Valley, Pennsylvania, from 1986 to 1988. Women were excluded from the Study of Osteoporotic Fractures if they had had bilateral hip replacement, were unable to walk without the assistance of another person, or were institutionalized. All participants gave written informed consent and attended a clinic visit during which questionnaires were given, interviews were conducted, and measurements were taken.

### Assessment of Physical Activity and Inactivity

Physical activity was assessed by using a modified version of the Harvard Alumni Questionnaire (27, 28). Participants were asked to report the frequency and duration of their participation in 33 physical activities during the past year. They were also asked to give the number of city blocks or the equivalent walked each day for exercise or as part of daily activities and how many flights of stairs they climbed. A summary estimate of total energy expenditure was calculated according to methods described elsewhere (27, 28). Leisure-time physical activities were attributed an intensity weighting of 5 kcal/min for low intensity, 7.5 kcal/min for medium intensity, or 10 kcal/min for high intensity; each city block walked was assigned 8 kcal/min, and each stair climbed was assigned 4 kcal/min. The total physical activity index, expressed in kilocalories per week, is the sum of kilocalories expended in sport and recreational activities, blocks walked, and stairs climbed.

To estimate physical activity related to household chores, participants were asked, "About how many hours per week do you usually spend doing heavy household chores, such as scrubbing floors, vacuuming, sweeping, yard work, gardening, or shoveling snow?" To estimate inactivity, women were asked how many hours per day they spend sitting upright.

### Other Measurements

Body weight and height were measured by using a balance-beam scale and a stadiometer. Bone mineral density (g/cm$^2$) was measured by using single-photon absorptiometry (OsteoAnalyzer, Siemens-Osteon, Wahiawa, Hawaii) at the distal radius and calcaneus. Hip abduction strength was measured by having the participant lay supine and exert a lateral force against a dynamometer (Sparks Instruments and Academics, Coralville, Iowa) placed 3 cm above the lateral malleolus and held by an observer. Details of these measurements have been reported elsewhere (9, 29).

Additional questions evaluated self-rated health; calcium intake from food; alcohol intake; and use of medications, including hormone replacement therapy, benzodiazepines, and anti-anxiety agents. To assess function, women were asked whether they had difficulty walking two to three blocks on level ground, walking up or down 10 steps, preparing meals, doing heavy housework, or shopping for groceries or clothing. They were also asked about their history of physician-diagnosed medical conditions, including osteoporosis, hypertension, diabetes, arthritis, and stroke.

### Assessment of Incident Fractures

Methods for identifying fractures have been published elsewhere (30). Participants were contacted every 4 months to ask whether they had had a fracture. Follow-up for fracture ascertainment was more than 99.5% complete. Radiographic reports and films were obtained to confirm hip fractures. Duration of hip and wrist fracture follow-up was calculated as the time to first occurrence of a fracture. Follow-up ranged from 0.2 to 9.6 years (mean, 7.6 years).

To measure vertebral fracture incidence, we obtained lateral radiographs of the thoracic and lumbar spine from 7238 women at baseline and an average of 3.7 years later. This sample was reduced because of inadequate technical measurements at baseline ($n$ = 129), failure or refusal to undergo radiography ($n$ = 341), failure to attend the follow-up clinic visit ($n$ = 1528), or death ($n$ = 468). Incident vertebral fracture was defined by morphometry as a reduction in the height of the anterior, middle, or posterior dimension of a vertebral body of 20% and at least 4 mm (31).

### Statistical Analysis

Women were classified according to quintiles of total physical activity. For heavy chores and sitting, for which there was a limited range of responses and data were skewed, women were grouped into approximate tertiles. To evaluate fracture risk according to intensity of energy expenditure, women were grouped into three exclusive groups: inactivity, low-intensity activity, and moderate to vigorous activity. Inactive women did not participate in any sport or recreational activity and did not walk for exercise. Women who did any sport or recreational activity or walked for exercise were grouped according to the highest intensity activity in which they participated. For example, if a woman reported gardening (light) and aerobic dance (moderate to vigorous), she would be classified in the moderate-to-vigorous intensity group. Additional analyses further stratified women within exercise intensity groups according to whether they did less than or more than 2 hours per week of total sport and recreational activity.

Analysis of covariance adjusted for age and chi-square tests of homogeneity were used to evaluate potential confounders across physical activity levels. Proportional hazards regression was done to calculate the relative risk (and 95% CIs) for hip and wrist fracture associated with physical activity level; the least active group for activity variables was the reference group. A multivariate model was also used that included age, weight, smoking status (current or never/past), use of estrogen therapy (current or never/past), self-rated health (five levels ranging from excellent to very poor), dietary calcium intake (mg/d), alcohol intake (drinks/wk), falls in the year before baseline (two or fewer than two), and functional difficulty (yes or no). These variables were selected on the basis of the a priori hypothesis that they could be related to both physical activity and risk for fracture. To determine whether any relations between physical activity and risk for fracture were explained by differences in bone density or muscle strength, calcaneal bone mineral density and hip abductor strength were added to the multivariate models in separate steps. We used logistic regression for vertebral fractures by applying a similar modeling strategy.

Additional analyses using different exclusion criteria were done to determine whether any relations among physical activity and fracture risk were explained by differences in health or functional status at baseline. To determine whether the relation between physical activity and hip fracture was explained by poor acute health among inactive women at baseline, analyses excluded 1) women who reported any difficulty walking two to three blocks on level ground, had a severe gait abnormality, or required a walking aid; 2) women with fair or poor self-rated health or history of diabetes, stroke, falls, or hip fracture before baseline measurement; and 3) women who had a fracture or died in the first 3 years after baseline measurement. All analyses were done using Statistical Analysis Software (SAS Institute, Inc., Cary, North Carolina).

## Results

Characteristics of the overall study population, stratified by quintile of total kilocalories of physical activity, are listed in **Table 1**. Women in lower quintiles of total physical activity were older, were heavier, were more likely to smoke, were less likely to use estrogen and alcohol, and had lower calcium intakes than women in higher quintiles ($P < 0.05$).

**Table 1. Characteristics of the Study Participants at Baseline**

| Variable | Full Sample | Lowest Quintile for Kilocalories Expended per Week in the Past Year | Second Quintile for Kilocalories Expended per Week in the Past Year | Third Quintile for Kilocalories Expended per Week in the Past Year | Fourth Quintile for Kilocalories Expended per Week in the Past Year | Highest Quintile for Kilocalories Expended per Week in the Past Year |
|---|---|---|---|---|---|---|
| Mean age, *y** | 71.7 ± 5.3† | 73.7 | 72.0 | 71.3 | 70.9 | 70.4 |
| Mean body weight, *kg**‡ | 67.1 ± 12.5† | 70.3 | 68.1 | 66.5 | 65.8 | 64.7 |
| Mean alcohol intake, *drinks/wk*‡§ | 1.9 ± 4.1† | 1.7 | 1.9 | 1.8 | 1.9 | 2.1 |
| Mean calcium intake, *mg/d**‡ | 714 ± 425† | 670 | 672 | 727 | 731 | 772 |
| Mean calcaneal bone mineral density, $g/cm^2$‡§ | 0.404 ± 0.09† | 0.400 | 0.402 | 0.403 | 0.404 | 0.411 |
| Mean distal radial bone mineral density, $g/cm^2$‡§ | 0.362 ± 0.08† | 0.361 | 0.360 | 0.360 | 0.360 | 0.369 |
| Current smoking %* | 10.0 | 13.1 | 10.8 | 9.9 | 8.9 | 7.2 |
| Current estrogen use, %* | 13.9 | 11.1 | 12.2 | 13.9 | 14.6 | 17.7 |
| Two or more falls in the past year, %§ | 10.7 | 12.0 | 9.6 | 9.9 | 10.2 | 11.9 |
| Difficulty walking, %* | 13.8 | 35.5 | 14.2 | 9.2 | 6.5 | 3.5 |
| Any functional difficulty, %* | 36.8 | 62.3 | 41.9 | 33.9 | 26.6 | 19.2 |
| Fair or poor self-rated health, %* | 16.8 | 30.2 | 20.2 | 15.8 | 10.3 | 8.0 |

* $P < 0.001$ for test of heterogeneity across groups.
† Value is the mean ± SD.
‡ Adjusted for age.
§ $P < 0.05$ for test of heterogeneity across groups.

**Table 2. Relative Risk for Hip Fracture Associated with Physical Activity**

| Variable | Patients | Fractures | Person-Years | Age-Adjusted Relative Risk (95% CI) | Multivariate-Adjusted Relative Risk (95% CI)* |
|---|---|---|---|---|---|
| | % | *n* | | | |
| Quintile of total physical activity | | | | | |
| Lowest (<340 kcal/wk) | 20 | 132 | 13 388 | 1.00 | 1.00 |
| Second (341–737 kcal/wk) | 20 | 87 | 14 549 | 0.73 (0.55–0.95) | 0.77 (0.58–1.02) |
| Third (738–1289 kcal/wk) | 20 | 82 | 14 821 | 0.73 (0.55–0.97) | 0.78 (0.59–1.04) |
| Fourth (1290–2201 kcal/wk) | 20 | 65 | 14 997 | 0.60 (0.45–0.81) | 0.64 (0.47–0.88) |
| Highest (>2201 kcal/wk) | 20 | 58 | 15 100 | 0.58 (0.42–0.80) | 0.64 (0.45–0.89) |
| *P* for trend | | | | 0.0002 | 0.003 |
| Sport or recreational activity | | | | | |
| None | 20 | 129 | 13 733 | 1.00 | 1.00 |
| Low intensity | 50 | 217 | 37 239 | 0.73 (0.58–0.90) | 0.76 (0.61–0.95) |
| Moderate-to-vigorous intensity | 30 | 80 | 22 390 | 0.55 (0.41–0.73) | 0.58 (0.43–0.79) |
| *P* for trend | | | | 0.0001 | 0.0004 |
| Hours of heavy chores per week | | | | | |
| <5 | 46 | 234 | 33 146 | 1.00 | 1.00 |
| 5–9 | 22 | 87 | 16 305 | 0.91 (0.71–1.17) | 0.93 (0.72–1.20) |
| >9 | 32 | 103 | 23 814 | 0.78 (0.61–0.98) | 0.78 (0.62–0.99) |
| *P* for trend | | | | 0.03 | 0.14 |
| Hours sitting per day | | | | | |
| <6 | 33 | 119 | 24 464 | 1.00 | 1.00 |
| 6–8 | 40 | 151 | 29 634 | 0.99 (0.78–1.26) | 0.98 (0.77–1.25) |
| >8 | 27 | 155 | 19 182 | 1.43 (1.12–1.82) | 1.37 (1.08–1.76) |
| *P* for trend | | | | 0.003 | 0.01 |

* Controlled for age, weight, smoking, estrogen replacement therapy, dietary calcium, falls, alcohol intake, self-rated health, and functional difficulty.

Women who were more active were less likely to report functional difficulties, had higher self-rated health, and had higher calcaneal and distal radius bone mineral density ($P < 0.001$) than did less active women. The proportion of women who fell twice or more per year was greater among the least active (12%) and most active quintiles (11.9%) than among the middle quintiles (9.6 to 10.2%). After an average follow-up period of 7.6 years (range, 0.2 to 9.6 years), 426 women had hip fractures and 523 had wrist fractures, for a yearly incidence of 5.8 hip fractures and 7.2 wrist fractures per 1000 person-years. Incident vertebral fractures occurred in 389 of the 7238 women who had spine films at baseline and 3.7 years later (cumulative incidence, 5.4%).

## Hip Fractures

Each increasing quintile of total physical activity was associated with a reduced relative risk for hip fracture. Women in the highest quintile had a 42% lower age-adjusted risk (relative risk, 0.58 [95% CI, 0.42 to 0.80]) compared with the least active quintile (**Table 2**). Increasing intensity of energy expenditure was also associated with a progressive decrease in hip fracture incidence: Women who reported participation in low-intensity and moderate-to-vigorous physical activity had 27% and 45% reductions in age-adjusted risk for hip fracture, respectively, compared with inactive women (**Table 2**).

When women were stratified within intensity groups according to whether they did more than 2 hours of physical activity per week (results not shown), the greatest reductions in risk were among women who did moderate-to-vigorous activities and at least 2 hours of sport and recreational activities per week (relative risk, 0.47 [CI, 0.32 to 0.68]). Women in the moderate-to-vigorous exercise group who reported fewer than 2 hours of activity per week had a relative risk of 0.76 (CI, 0.53 to 1.10), whereas those who reported only low-intensity activities for less than 2 hours and more than 2 hours had relative risks of 0.77 (CI, 0.60 to 0.99) and 0.74 (CI, 0.56 to 0.98), respectively.

Graded reductions in hip fracture risk were also seen for women who reported more hours per week of heavy chores. Women who reported at least 10 hours per week had a 22% reduction in risk (CI, 2% to 39%) compared with women who reported less than 5 hours per week. The more hours a woman spent sitting per day, the higher her risk for hip fracture: Women who sat for at least 9 hours per day had a 43% higher risk (CI, 12% to 82%) than those who sat for less than 6 hours per day.

Adjustment for smoking, estrogen therapy, body weight, number of falls, intake of calcium and alcohol, functional difficulties, and self-rated health at baseline only slightly weakened the relation between physical activity and risk for hip fracture (4% to 6%). After adjustment for these confounders, very active women (fourth and fifth quintiles) had a 36% reduction in risk for hip fracture (multivariate relative risk, 0.64 [CI, 0.45 to 0.89]) compared with inactive women (lowest quintile). With the exception of those for heavy chores, tests for trend remained significant (**Table 2**).

### Wrist Fractures

Women with higher levels of total physical activity and those who reported more heavy chores per week tended to have a reduced risk for wrist fracture, but these relations were not statistically significant ($P > 0.2$ for total physical activity; multivariate $P$ for trend for heavy chores, 0.09) (**Table 3**). Neither intensity of energy expenditure nor hours sitting per week were significantly associated with risk for wrist fracture. Addition of other covariates to the regression models did not alter these findings appreciably.

### Vertebral Fractures

Total physical activity was not significantly associated with risk for vertebral fracture (**Table 4**). Although women in the middle quintile had a significantly reduced odds ratio for vertebral fracture (0.63 [CI, 0.44 to 0.88]), these findings were not consistent across quintiles, and there was no evidence of a linear trend ($P > 0.2$). Intensity of physical activity, however, was inversely associated with odds of vertebral fracture (**Table 4**). Compared with inactive women, women who did moderate-to-vigorous exercise had a 33% reduction (CI, 6% to 51%) in vertebral fracture odds after multivariate adjustment. This reduction was apparent in women who reported less than 2 hours of sport and recreational activity per week (odds ratio, 0.70 [CI, 0.45 to 1.07]) and those who reported more than 2 hours of sport and recreational activity per week (odds ratio, 0.67 [CI, 0.46 to 0.97]) (results not shown). Reported hours of heavy chores per week and sitting per day were not significantly associated with vertebral fracture (**Table 4**).

### Additional Analyses

We evaluated models in which calcaneal bone mineral density and hip abduction strength were added to the multivariate model separately and in combination to determine whether bone muscle density or muscle strength intervened in the relation between physical activity and hip fracture (**Table 5**). Adding these variables weakened the associations between physical activity quintile and risk for fracture by 3% to 11%. Risk estimates were not appreciably altered in separate multivariate models that excluded women with mobility difficulties, comorbid conditions, poor self-rated health, and previous fractures and women who were censored (had hip fracture or died) in the first 3 years of follow-up.

## Discussion

In this prospective, 7.6-year evaluation of 9704 women, higher levels of physical activity were associated with a reduced incidence of hip fracture. This dose–response relation amounted to a 36% reduction in risk for hip fracture for women in the highest two quintiles of total physical activity and a 42% reduction in women who did moderately intense or vigorous recreational activities. Multivariate adjustment and follow-up analyses done using several exclusion criteria indicated that the relation of physical activity to hip fracture was not confounded by

**Table 3. Relative Risk for Wrist Fracture Associated with Physical Activity**

| Variable | Patients | Fractures | Person-Years | Age-Adjusted Relative Risk (95% CI) | Multivariate-Adjusted Relative Risk (95% CI)* |
|---|---|---|---|---|---|
| | % | *n* | | | |
| Quintile of total physical activity | | | | | |
| Lowest (<340 kcal/wk) | 20 | 108 | 13 332 | 1.00 | 1.00 |
| Second (341–737 kcal/wk) | 20 | 104 | 14 362 | 0.94 (0.71–1.23) | 0.92 (0.70–1.22) |
| Third (738–1289 kcal/wk) | 20 | 109 | 14 639 | 0.98 (0.75–1.28) | 0.95 (0.71–1.25) |
| Fourth (1290–2201 kcal/wk) | 20 | 101 | 14 705 | 0.91 (0.69–1.20) | 0.90 (0.67–1.20) |
| Highest (>2201 kcal/wk) | 20 | 97 | 14 863 | 0.88 (0.67–1.16) | 0.85 (0.63–1.15) |
| *P* for trend | | | | >0.2 | >0.2 |
| Sport or recreational activity | | | | | |
| None | 20 | 95 | 13 747 | 1.00 | 1.00 |
| Low intensity | 50 | 270 | 36 771 | 1.11 (0.88–1.40) | 1.10 (0.87–1.40) |
| Moderate-to-vigorous intensity | 30 | 158 | 21 878 | 1.13 (0.88–1.47) | 1.13 (0.86–1.49) |
| *P* for trend | | | | >0.2 | >0.2 |
| Hours of heavy chores per week | | | | | |
| <5 | 46 | 265 | 32 699 | 1.00 | 1.00 |
| 5–9 | 22 | 100 | 16 149 | 0.79 (0.63–1.00) | 0.79 (0.63–1.00) |
| >9 | 32 | 157 | 23 451 | 0.86 (0.71–1.05) | 0.86 (0.71–1.05) |
| *P* for trend | | | | 0.11 | 0.09 |
| Hours sitting per day | | | | | |
| <6 | 33 | 174 | 24 075 | 1.00 | 1.00 |
| 6–8 | 40 | 193 | 29 247 | 0.90 (0.74–1.11) | 0.91 (0.74–1.12) |
| >8 | 27 | 156 | 18 986 | 1.10 (0.89–1.37) | 1.09 (0.87–1.36) |
| *P* for trend | | | | >0.2 | >0.2 |

* Controlled for age, weight, smoking, estrogen replacement therapy, dietary calcium, falls, alcohol intake, self-rated health, and functional difficulty.

**Table 4. Odds Ratios for Vertebral Fracture Associated with Physical Activity**

| Variable | Patients | Fractures | Women | Age-Adjusted Odds Ratio (95% CI) | Multivariate-Adjusted Odds Ratio (95% CI)* |
|---|---|---|---|---|---|
| | % | n | | | |
| Quintile of total physical activity | | | | | |
| Lowest (<340 kcal/wk) | 16 | 87 | 1177 | 1.00 | 1.00 |
| Second (340–737 kcal/wk) | 20 | 76 | 1427 | 0.78 (0.56–1.07) | 0.76 (0.54–1.05) |
| Third (738–1289 kcal/wk) | 20 | 59 | 1473 | 0.63 (0.44–0.88) | 0.63 (0.44–0.89) |
| Fourth (1290–2201 kcal/wk) | 21 | 90 | 1521 | 0.97 (0.71–1.33) | 0.99 (0.72–1.38) |
| Highest (>2201 kcal/wk) | 22 | 75 | 1592 | 0.80 (0.58–1.11) | 0.84 (0.59–1.19) |
| *P* for trend | | | | >0.2 | >0.2 |
| Sport or recreational activity | | | | | |
| None | 18 | 86 | 1272 | 1.00 | 1.00 |
| Low intensity | 50 | 218 | 3638 | 0.98 (0.75–1.27) | 0.99 (0.76–1.29) |
| Moderate-to-vigorous intensity | 32 | 85 | 2328 | 0.65 (0.48–0.89) | 0.67 (0.49–0.94) |
| *P* for trend | | | | 0.005 | 0.01 |
| Hours of heavy chores per week | | | | | |
| <5 | 45 | 184 | 3225 | 1.00 | 1.00 |
| 5–9 | 22 | 81 | 1609 | 0.99 (0.75–1.29) | 1.04 (0.79–1.38) |
| >9 | 33 | 124 | 2394 | 1.04 (0.82–1.32) | 1.09 (0.85–1.39) |
| *P* for trend | | | | >0.2 | >0.2 |
| Hours sitting per day | | | | | |
| <6 | 34 | 111 | 2419 | 1.00 | 1.00 |
| 6–8 | 41 | 174 | 2955 | 1.25 (0.98–1.60) | 1.22 (0.95–1.56) |
| >8 | 26 | 103 | 1860 | 1.12 (0.85–1.48) | 1.09 (0.82–1.44) |
| *P* for trend | | | | >0.2 | >0.2 |

* Controlled for age, weight, smoking, estrogen replacement therapy, dietary calcium, falls, alcohol intake, self-rated health, and functional difficulty.

health status, functional status, history of falling, or other health behaviors.

These findings are consistent with previous case–control studies and one prospective study in which moderately active women had statistically significant 40% to 50% reductions in risk for hip fracture compared with sedentary women (18, 21, 22, 24). These results also corroborate the earlier finding from the Study of Osteoporotic Fractures that women who walked for exercise had a 30% reduced risk for fracture compared with those who did not walk for exercise after an average follow-up of 4.1 years (10). Other studies have suggested that physical activity protects against osteoporotic fractures, but these studies failed to find statistical significance, lacked comprehensive physical activity assessment, or did not control for potential confounding behaviors or health status (25, 26).

Our study expanded on previous research by evaluating the characteristics of physical activity and their relation to risk for fracture. The association of total physical activity with risk for hip fracture seemed to be related to both the amount and the intensity of physical activity. Women who did moderately intense or vigorous activities, such as aerobic and other forms of dance, tennis, and weight training, had greater reductions in hip and vertebral fracture risk than did women who did lighter activities, such as walking and gardening, particularly if they were active for at least 2 hours per week. This decrease in risk among moderately and vigorously active women compared with women who did low-intensity activities for a similar duration suggests that vigorous activity was not simply a marker of greater total duration.

Physical activity may prevent hip fractures in several ways. Exercise may reduce the likelihood of falling or may enable a protective response in the event of a fall through enhanced balance, reaction time, coordination, mobility, and muscle strength (15–17, 32). Exercise may also enhance bone mineral density or the structural integrity of bone, re-

**Table 5. Relation between Total Physical Activity Quintile and Risk for Fracture after Separate Adjustment for Age, Bone Mineral Density, and Hip Strength**

| Quintile of Total Physical Activity | Age-Adjusted Relative Risk (95% CI) | Relative Risk Adjusted for Age and Calcaneal Bone Mineral Density (95% CI) | Relative Risk Adjusted for Age and Hip Muscle Strength (95% CI) | Relative Risk Adjusted for Age, Calcaneal Bone Mineral Density, and Hip Strength (95% CI) |
|---|---|---|---|---|
| Lowest | 1.00 | 1.00 | 1.00 | 1.00 |
| Second | 0.73 (0.55–0.95) | 0.77 (0.58–1.01) | 0.76 (0.58–1.00) | 0.79 (0.60–1.04) |
| Third | 0.73 (0.55–0.97) | 0.77 (0.58–1.02) | 0.76 (0.57–1.01) | 0.79 (0.60–1.05) |
| Fourth | 0.60 (0.45–0.81) | 0.64 (0.47–0.86) | 0.64 (0.48–0.87) | 0.66 (0.49–0.90) |
| Highest | 0.58 (0.42–0.80) | 0.64 (0.47–0.89) | 0.64 (0.46–0.88) | 0.69 (0.50–0.94) |

ducing the likelihood of fracture in the event of a fall (11–14). Although our analyses did not attempt to explain how physical activity prevents fractures, the fact that physical activity was related to fracture risk after we controlled for calcaneal bone mineral density, hip strength, and number of falls suggests that the link between physical activity and hip fracture is multifactorial and is not completely explained by its effects on bone mass and muscle strength.

We found that total physical activity was not significantly related to the incidence of wrist or vertebral fractures. For wrist fractures, moderate-to-vigorous activities were related to a nonsignificantly increased risk for fracture. These findings may reflect the fact that osteoporotic fractures have heterogeneous causes (32). It has been suggested that more agile women are more likely to extend their hands during a fall to absorb the impact, causing wrist fractures but preventing other types of fractures (32). Thus, physical activity may have competing effects on the risk for wrist fracture, enhancing bone density but putting some women at greater risk for falling. Vertebral fractures, on the other hand, may depend more on deficits in bone density and may be less influenced by the tendency to fall than are hip or wrist fractures. Physical activity may not influence bone density sufficiently to have an appreciable effect on vertebral fractures.

Our study had several limitations. The primarily white, independently living, female study sample may limit generalization to other populations. Most physical activity assessment tools, including the Paffenbarger questionnaire used in this study, were originally developed for younger men and may not be sensitive to differences at the low end of the physical activity spectrum. However, Cauley and colleagues (33) found this questionnaire to be reliable and valid in older women. We did not comprehensively assess neuroleptic medications, which could affect the risk for falls, but multivariate models adjusted for falls at baseline and additional analyses that controlled for use of benzodiazepines and anxiety medications (results not shown) did not alter these findings.

The sample size was reduced for vertebral fractures because these fractures were assessed by using vertebral radiography at specific time points (baseline and 3.7 years later). Therefore, women who died or did not attend the follow-up visit were not included in this analysis. Follow-up analyses indicated that women who did not attend the follow-up visit were less active (median kilocalories expended, 719 compared with 1071 for those who attended the visits) and were more likely to have hip fractures (age-adjusted odds ratio, 1.29 [CI, 1.05 to 1.60]). If these women also had higher vertebral fracture rates, our findings may have underestimated the relation between physical activity and risk for vertebral fracture. Despite this limitation, this is the first prospective evaluation of physical activity and vertebral fractures, perhaps because it is difficult to measure vertebral fracture incidence (31).

In the absence of a randomized design, we cannot rule out the possibility of selection bias or residual confounding whereby women with higher bone density, muscle strength, and physical function choose a more active lifestyle. However, multivariable control for factors related to health and functional status and separate evaluation of models excluding women on the basis of mobility factors, health status, and early fracture or death did not alter these findings. It is also possible that higher-intensity activities are more easily recalled than lower-intensity activities; this could explain in part the observed gradient in fracture risk across exercise intensity groups.

In this prospective study of physical activity and risk for fracture in older women, physical activity was related to a reduced risk for hip fracture but was less related to wrist and vertebral fractures. The findings of a dose–response relation between physical activity and hip fracture could have important implications for fracture prevention and underscores the need to enhance physical activity among older women. Although we found the greatest risk reductions among women who participated in moderately intense or vigorous activities, such as tennis or aerobic dance, women who did lower-intensity activities, such as walking, gardening, or social dancing, for at least 1 hour per week also had significant reductions in risk for hip fracture. The latter activities were also the activities of choice for most women in the higher quintiles of physical activity, who simply tended to do more of them (that is, ≥2 hours per week). Thus, low-intensity activities may be the most prudent recommendation for sedentary older women. Future research should evaluate whether different types or patterns of physical activity affect other types of osteoporotic fractures and whether they do so primarily through effects on the skeleton, muscular fitness, or balance or through other mechanisms.

## Appendix: Investigators in the Study of Osteoporotic Fractures Research Group

University of California, San Francisco (*Coordinating Center*): S.R. Cummings (*Principal Investigator*), M.C. Nevitt (*Co-Investigator*), D.G. Seeley (*Project Director*), D.M. Black (*Study Statistician*), H.K. Genant (*Director, Central Radiology Laboratory*), C. Arnaud, D. Bauer, W. Browner, L. Christianson, M. Dockrell, C. Fox, R. Gore, S. Harvey, M. Jaime-Chavez, L. Laidlaw, R. Lipschutz, L.

Lui, G. Milani, L. Palermo, R. San Valentin, K. Stone, H. Tabor, D. Tanaka, and C. Yeung.

University of Maryland: J.C. Scott (*Principal Investigator*), R. Sherwin (*Co-Investigator*), M.C. Hochberg (*Co-Investigator*), J. Lewis (*Project Director*), E. Peddicord (*Clinic Coordinator*), A. Bauer, C. Boehm, G. Cullum, L. Finazzo, M.E. Flaks, T. Ford, D. Harris, B. Hohman, E. Oliner, T. Page, J. Schlossberg, C. Shaffer, A. Trimble, and S. Trusty.

University of Minnesota: K. Ensrud (*Principal Investigator*), P. Schreiner (*Co-Investigator*), C. Bell (*Project Director*), E. Mitson (*Clinic Coordinator*), C. Bird, D. Blanks, S. Estill, S. Fillhouer, S. Fincham, J. Griffith, J. Hansen, F. Imker-Witte, K. Jacobson, K. Kiel, K. Knauth, N. Nelson, E. Penland-Miller, and M. Riley-Alves.

University of Pittsburgh: J.A. Cauley (*Principal Investigator*), L.H. Kuller (*Co–Principal Investigator*), M. Vogt (*Co-Investigator*), L. Harper (*Project Director*), L. Buck (*Clinic Coordinator*), C. Bashada, D. Cusick, G. Engleka, A. Githens, M. Gorecki, K. McCune, D. Medve, M. Nasim, C. Newman, S. Rudovsky, and N. Watson.

The Kaiser Permanente Center for Health Research, Portland, Oregon: E. Harris (*Principal Investigator and Project Director*), W.M. Vollmer (*Co-Investigator*), E. Orwoll (*Co-Investigator*), H. Nelson (*Co-Investigator*), K. Crannell (*Project Administrator and Clinic Coordinator*), J. Bender, A. Doherty, K. Easter, M. Erwin, F. Heinith, J. Kann, K. Redden, C. Romero, K. Snider, and C. Souvanlasy.

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|---|---|
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| 著 者 | Gregg EW, Cauley JA, Seeley DG, Ensrud KE, Bauer DC. |
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| 発行年 | 1998 |
| PubMedリンク | http://www.ncbi.nlm.nih.gov/pubmed/9669990 |

**対象の内訳**

| | ヒト | 動物 | 地 域 | 欧米 | 研究の種類 | 縦断研究 |
|---|---|---|---|---|---|---|
| 対象 | 一般健常者 | 空白 | | (　　) | | コホート研究 |
| 性別 | 女性 | (　　) | | (　　) | | (　　) |
| 年齢 | 65歳以上 | | | (　　) | | 前向き研究 |
| 対象数 | 5000～10000 | 空白 | | (　　) | | (　　) |

| 調査の方法 | 実測 | (　　) | | | | |
|---|---|---|---|---|---|---|
| アウトカム 予 防 | な し | な し | な し | 転倒・骨折予防 | (　　) | (　　) |
| アウトカム 維持・改善 | な し | な し | な し | な し | (　　) | (　　) |

**図 表**

**Table 2. Relative Risk for Hip Fracture Associated with Physical Activity**

| Variable | Patients | Fractures | Person-Years | Age-Adjusted Relative Risk (95% CI) | Multivariate-Adjusted Relative Risk (95% CI)* |
|---|---|---|---|---|---|
| | % | n | | | |
| Quintile of total physical activity | | | | | |
| Lowest (<340 kcal/wk) | 20 | 132 | 13 388 | 1.00 | 1.00 |
| Second (341–737 kcal/wk) | 20 | 87 | 14 549 | 0.73 (0.55–0.95) | 0.77 (0.58–1.02) |
| Third (738–1289 kcal/wk) | 20 | 82 | 14 821 | 0.73 (0.55–0.97) | 0.78 (0.59–1.04) |
| Fourth (1290–2201 kcal/wk) | 20 | 65 | 14 997 | 0.60 (0.45–0.81) | 0.64 (0.47–0.88) |
| Highest (>2201 kcal/wk) | 20 | 58 | 15 100 | 0.58 (0.42–0.80) | 0.64 (0.45–0.89) |
| *P* for trend | | | | 0.0002 | 0.003 |
| Sport or recreational activity | | | | | |
| None | 20 | 129 | 13 733 | 1.00 | 1.00 |
| Low intensity | 50 | 217 | 37 239 | 0.73 (0.58–0.90) | 0.76 (0.61–0.95) |
| Moderate-to-vigorous intensity | 30 | 80 | 22 390 | 0.55 (0.41–0.73) | 0.58 (0.43–0.79) |
| *P* for trend | | | | 0.0001 | 0.0004 |
| Hours of heavy chores per week | | | | | |
| <5 | 46 | 234 | 33 146 | 1.00 | 1.00 |
| 5–9 | 22 | 87 | 16 305 | 0.91 (0.71–1.17) | 0.93 (0.72–1.20) |
| >9 | 32 | 103 | 23 814 | 0.78 (0.61–0.98) | 0.78 (0.62–0.99) |
| *P* for trend | | | | 0.03 | 0.14 |
| Hours sitting per day | | | | | |
| <6 | 33 | 119 | 24 464 | 1.00 | 1.00 |
| 6–8 | 40 | 151 | 29 634 | 0.99 (0.78–1.26) | 0.98 (0.77–1.25) |
| >8 | 27 | 155 | 19 182 | 1.43 (1.12–1.82) | 1.37 (1.08–1.76) |
| *P* for trend | | | | 0.003 | 0.01 |

* Controlled for age, weight, smoking, estrogen replacement therapy, dietary calcium, falls, alcohol intake, self-rated health, and functional difficulty.

**図表掲載箇所** P84, Table2

**概 要（800字まで）**

65歳以上の女性9704名を対象に、平均7.6年間の追跡調査を行い、身体活動と骨折との関係を調べた研究である。身体活動は、過去1年における33の身体活動の参加について頻度と期間が質問された。また、毎日の活動の一部や運動として毎日歩くブロック数と、階段を何段上るかかを聞き取った。余暇身体活動の低強度は5kcal/min、中強度は7.5kcal/min、高強度は10kcal/min、歩行は8kcal/min、階段は4kcal/minで計算された。骨折については、股関節、腰部、脊椎骨折が評価された。股関節骨折に関して、総身体活動が最も少ない群（340kcal/wk）と比較して、341-737, 738-1289, 1290-2201, 2201kcal/wkの群では、骨折のリスクが、0.77(0.58-1.02), 0.78(0.59-1.04), 0.64 (0.47-0.88), 0.64(0.45-0.89)の低下が認められた。腰部および脊椎に関しては、リスクの有意な低下は認められなかった。また股関節骨折に関しては、スポーツやレクレーション活動、きつい家事活動、座位時間とも関連していた。

**結 論（200字まで）**

高齢女性において、身体活動は股関節骨折に関しては予防的効果が示されたものの、腰部や脊椎の骨折に関しては関連が認められなかった。

**エキスパートによるコメント（200字まで）**

転倒・骨折は、我が国における要介護の原因の一つであり、これらを高齢者において予防することは非常に重要な課題である。このような身体活動と骨折予防との関連が明らかになることで、今後の介護予防に対する取組の中での身体活動の推進がさらに加速されることを期待する。

担当者 村上晴香

Research article

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# Relationship between physical activity and stiff or painful joints in mid-aged women and older women: a 3-year prospective study

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## Abstract

This prospective study examined the association between physical activity and the incidence of self-reported stiff or painful joints (SPJ) among mid-age women and older women over a 3-year period. Data were collected from cohorts of mid-age (48–55 years at Time 1; *n* = 4,780) and older women (72–79 years at Time 1; *n* = 3,970) who completed mailed surveys 3 years apart for the Australian Longitudinal Study on Women's Health. Physical activity was measured with the Active Australia questions and categorized based on metabolic equivalent value minutes per week: none (<40 MET.min/week); very low (40 to <300 MET.min/week); low (300 to <600 MET.min/week); moderate (600 to <1,200 MET.min/week); and high (1,200+ MET.min/week). Cohort-specific logistic regression models were used to examine the association between physical activity at Time 1 and SPJ 'sometimes or often' and separately 'often' at Time 2. Respondents reporting SPJ 'sometimes or often' at Time 1 were excluded from analysis. In univariate models, the odds of reporting SPJ 'sometimes or often' were lower for mid-age respondents reporting low (odds ratio (OR) = 0.77, 95% confidence interval (CI) = 0.63–0.94), moderate (OR = 0.82, 95% CI = 0.68–0.99), and high (OR = 0.75, 95% CI = 0.62–0.90) physical activity levels and for older respondents who were moderately (OR = 0.80, 95% CI = 0.65–0.98) or highly active (OR = 0.83, 95% CI = 0.69–0.99) than for those who were sedentary. After adjustment for confounders, these associations were no longer statistically significant. The odds of reporting SPJ 'often' were lower for mid-age respondents who were moderately active (OR = 0.71, 95% CI = 0.52–0.97) than for sedentary respondents in univariate but not adjusted models. Older women in the low (OR = 0.72, 95% CI = 0.55–0.96), moderate (OR = 0.54, 95% CI = 0.39–0.76), and high (OR = 0.61, 95% CI = 0.46–0.82) physical activity categories had lower odds of reporting SPJ 'often' at Time 2 than their sedentary counterparts, even after adjustment for confounders. These results are the first to show a dose–response relationship between physical activity and arthritis symptoms in older women. They suggest that advice for older women not currently experiencing SPJ should routinely include counseling on the importance of physical activity for preventing the onset of these symptoms.

## Introduction

Arthritis is a musculoskeletal condition of the joints. In Australia, it is a leading cause of pain and disability [1], affecting 3.4 million adults or 17% of the population [2]. Estimates are that by 2020 arthritis will affect 4.6 million Australians, or 20% of the adult population [2]. The current prevalence in Australia is slightly less than that in the United States, where 21% of the population has arthritis [3], making it the most prevalent chronic condition for mid-age and older people in the United States [4]. As in the United States, more Australian women than men have arthritis [2,4,5], and the incidence and prevalence of arthritis increase with age [4-6]. As the proportion of older people in both countries continues to rise, more individuals, particularly women, will be at risk of developing arthritis, and the burden of this disease will continue to increase. Identifying modifiable risk factors for the effects of arthritis is crucial to the prevention of its associated disability, especially in mid-age women and in older women.

Physical activity has been identified as a potentially modifiable risk factor in prospective population-based studies assessing risk factors for arthritis among women [5,7-9]. The results from

ALSWH = Australian Longitudinal Study on Women's Health; BMI = body mass index; CI = confidence interval; OR = odds ratio; MET = metabolic equivalent value; SPJ = stiff or painful joints.

these studies, however, are equivocal. One study [9] found walking to be protective against radiographic evidence of arthritis in women (defined as joint space narrowing), whereas others [5,7] found no association between leisure-time physical activity and risk of self-reported arthritis in women. In contrast, being in the highest quartile of total daily physical activity in the Framingham cohort study [8] *increased* the risk of incident radiographic arthritis in women in the short term (8 years), although not over a longer time period (20–40 years). Results of studies assessing risk factors for arthritis in male and female athletes indicate increased risk among competitive elite athletes in some sports, such as soccer, football, and rugby [10-13]. Together, the findings of these studies suggest that high levels of some competitive athletic sports increase the risk of arthritis but that moderate to vigorous leisure-time physical activities in nonathletes may have no association or reduce risk of the disease. Few studies have examined the association between physical activity and risk of arthritis in nonathletes, however, so this association is unclear.

The Australian Longitudinal Study on Women's Health (ALSWH) provides an opportunity to evaluate the prospective association between physical activity and increased risk of arthritis symptoms in two large cohorts of women. This prospective cohort study includes questions about walking and about moderate-intensity and vigorous-intensity physical activities. It also asks about physician diagnosis of arthritis and about women's experiences of a range of symptoms, including 'stiff or painful joints.' As there are more than 100 types of arthritis, all characterized by pain, stiffness, and disability [14], the self-report of these symptoms allows for the identification of women who have early and mild symptoms of arthritis, but have not yet been diagnosed with the disease. This is important because women with symptoms of arthritis do not always seek a professional diagnosis: estimates from the US National Health Interview Survey suggest that 16% of adults reporting arthritis have never seen a physician about this condition [15]. Indeed, many arthritis sufferers treat their symptoms with nonprescription medications or rely on alternative therapies [16-19]. There is also evidence to suggest that arthritis symptoms predict disability more strongly than radiological changes, which may not always be apparent in the early stages of the disease [20]. In exploring risk factors that contribute to the development of arthritis, the assessment of arthritis symptoms, therefore, may provide a more relevant and accurate indicator of the onset of the disease.

The aim of this study was to explore the association between physical activity and incidence of self-reported 'stiff or painful joints' in the mid-age and older cohorts of the ALSWH. Understanding the role of this potentially modifiable risk factor could be important in the development of strategies for the prevention of the disabling symptoms associated with arthritis in women.

## Materials and methods

### The ALSWH sample

The ALSWH is an ongoing study of the health and well-being of Australian women. As reported elsewhere [21], in 1996 random samples of women aged 18–23 years ('young'), 45–50 years ('mid-age'), and 70–75 years ('older') were drawn from the national Medicare health insurance database, which includes all Australian residents as well as immigrants and refugees. Women from rural and remote areas were intentionally over-represented. Data from the 2001 (Time 1 (T1)) and 2004 (Time 2 (T2)) surveys of the mid-age cohort and from the 1999 (T1) and 2002 (T2) surveys of the older cohort were used in the analyses reported here. The study was approved by the University of Newcastle Ethics Committee. Informed consent was received from all respondents. More details about the study can be found online [22].

### Assessment of stiff or painful joints

Respondents were asked whether they had experienced 'stiff or painful joints' in the past 12 months. Response options of 'never,' 'rarely,' 'sometimes,' or 'often' were dichotomized into 'sometimes or often,' or 'never or rarely' and also into 'often' or 'not often' (never, rarely, sometimes) to examine the sensitivity of the categorization chosen for determining the women at risk for incident joint pain. It was hypothesized that the women experiencing stiff or painful joints 'often' were those most likely to be suffering early symptoms of arthritis, and therefore physical activity would be more strongly associated with the onset of experiencing symptoms 'often' than 'sometimes or often.'

Because the validity of this item had not been examined, its predictive validity was assessed by exploring its ability to predict self-reported physician-diagnosed arthritis and physical functioning. Arthritis was assessed at T2 by asking 'In the last 3 years, have you been diagnosed with or treated for arthritis (including osteoarthritis, rheumatoid arthritis)?' [23]. Respondents who reported at T1 that they had been diagnosed with or treated for arthritis by a physician were excluded. In univariate logistic regression models, the odds of reporting arthritis at T2 were significantly increased among the mid-age women who reported stiff or painful joints 'sometimes or often' at T1 (odds ratio (OR) = 2.48, 95% confidence interval (CI) = 2.16–2.83, $P < 0.001$) and, similarly, among those who reported these symptoms 'often' (OR = 2.56, 95% CI = 2.13–3.09, $P < 0.001$). In the older women, reporting stiff or painful joints 'sometimes or often' also increased the odds of reporting arthritis (OR = 3.94, 95% CI = 3.38–4.58, $P < 0.001$), and reporting these symptoms 'often' increased the odds even more (OR = 5.28, 95% CI = 4.23–6.61, $P < 0.001$).

Physical function was measured with the Physical Function subscale of the Medical Outcomes Study Short Form [24]. A lower score on the subscale represents lower physical functioning. In univariate linear regression models, reporting stiff or painful joints 'sometimes or often' at T1 was associated with significantly lower physical function scores at T2 in both the mid-age women ($B$ = -7.78, 95% CI = -8.58 to -6.99, $P <$ 0.001) and older women ($B$ = -14.15, 95% CI = -15.92 to -12.38, $P < 0.001$). Reporting the symptoms 'often' was associated with even lower physical function scores in the mid-age women (B = -14.37, 95% CI = -15.69 to -13.04, $P < 0.001$) and older women ($B$ = -23.57, 95% CI = -26.42 to -20.73, $P < 0.001$).

### Assessment of physical activity

Survey items to assess physical activity were based on those developed for the Active Australia survey in 1997, a validated and reliable measure [25-27]. The frequency and time duration (in at least 10-min sessions) in the previous week spent walking briskly (for travel or leisure), in moderate-intensity leisure-time physical activities, and in vigorous leisure-time physical activities were reported. A physical activity score was calculated as the sum of the products of total time in each of the three categories of activity and the metabolic equivalent value (MET) assigned to each category [28,29]: (walking minutes × 3.0 METs) + (moderate physical activity minutes × 4.0 METs) + (vigorous physical activity minutes × 7.5 METs), in accordance with the Compendium of Physical Activities [30]. Physical activity was then categorized based on total MET minutes per week: none (<40 MET.min/week); very low (40 to <300 MET.min/week); low (300 to <600 MET.min/week); moderate (600 to <1,200 MET.min/week); and high (1,200+ MET.min/week).

### Assessment of potential confounding factors

A list of variables considered potential confounders in the relationship between physical activity and stiff or painful joints was derived from previous studies [31] (see Table 1). Area of residence categories were derived from postcodes. To measure the number of chronic diseases, respondents were asked whether they had been told by a doctor in the previous 3 years that they had any of the diseases listed. The list of diseases was adapted from the Australian 1989–1990 National Health Survey [23]. Diagnosis of depression was determined by a single item modified from the Australian 1989–1990 National Health Survey [23]: 'In the last 3 years, have you been told by a doctor that you have depression?' ('yes' or 'no').

Height without shoes and weight without clothes or shoes were reported, and the body mass index (BMI) was calculated as weight divided by height squared. The BMI was then categorized as underweight (BMI <20 kg/m$^2$), healthy weight (BMI ≥20 and <25 kg/m$^2$), overweight (BMI ≥25 and <30 kg/m$^2$), or obese (BMI ≥ 30 kg/m$^2$) in accordance with the Australian National Health and Medical Research Council classification system [32]. The World Health Organization classification of a BMI less than 18.5 kg/m$^2$ as 'underweight' [33] was not used because few in the samples had a BMI meeting this criterion at the first ALSWH survey.

### Data analysis

The initial analysis samples were mid-age women and older women who did not report having stiff or painful joints 'sometimes' or 'often' at T1. From this group, respondents were excluded if they had missing physical activity data at T1 or had missing stiff or painful joint data at T2. Differences between women included in our analysis and those excluded were examined using Pearson's chi-square tests for categorical variables and an independent *t* test for the one continuous variable (age). Univariate associations between each potential confounding variable at T1 and the two outcomes (having stiff or painful joints 'sometimes or often;' having these symptoms 'often') at T2 were computed separately for each cohort. Variables having a statistically significant association with at least one outcome in at least one cohort ($P < 0.05$) were included in multivariable logistic regression models computed to evaluate the association between physical activity and stiff or painful joints in each cohort, after adjusting for the other factors. For each confounding variable for which some respondents' data were missing, a missing category was included in all analyses to maintain as large a sample as possible, and the missing category was compared with the reference category in the same way the other categories were compared with the reference category. Interactions between physical activity and each potential confounding variable were examined, but none were significant. No interaction terms were therefore included in the final models. Odds ratios and 95% confidence intervals were computed for all models.

## Results

### Samples

In total, 5,650 (52.2%) mid-age women and 5,207 (54.9%) older women reported having stiff or painful joints 'never' or 'rarely' at T1. Of these, 475 mid-age women and 843 older women were excluded because they did not participate in the T2 survey. Another 208 mid-age women and 199 older women were excluded because they had missing values for physical activity at T1. After the additional exclusion of women who did not report whether they had painful or stiff joints at T2 (187 mid-age women and 195 older women excluded), data from 4,780 mid-age women and 3,970 older women were included in these analyses.

Meaningful and statistically significant differences were seen between those who were included and those who were excluded from the analysis (see Table 1). In both cohorts, women who were excluded from the analysis were less physically active and had lower levels of education ($P < 0.001$). These women were also were more likely to live in a large town, to have been born in a non-English-speaking country, to have four or more chronic diseases, and to be smokers than women who were included ($P < 0.05$). Older women who were excluded were also more likely to have depression ($P <$ 0.001).

**Table 1**

**Characteristics of respondents who reported stiff or painful joints 'never' or 'rarely' at Time 1**

| | Mid-age women ($n$ = 5,650) | | | Older women ($n$ = 5,207) | | |
|---|---|---|---|---|---|---|
| Variable | Respondents included $n$ = 4,780) | Respondents excluded[a] ($n$ = 870) | $P$ value[b] | Respondents included ($n$ = 3,970) | Respondents excluded[a] ($n$ = 1,237) | $P$ value[b] |
| Age (years, mean ± standard deviation) | 52.53 ± 1.49 | 52.57 ± 1.52 | 0.366 | 75.39 ± 1.51 | 75.60 ± 1.51 | <0.001 |
| Education (%) | | | <0.001 | | | <0.001 |
| Less than high school | 13.5 | 18.7 | | 26.8 | 34.7 | |
| Some high school | 47.8 | 50.9 | | 52.7 | 47.7 | |
| Completed high school | 20.5 | 17.4 | | 11.6 | 9.2 | |
| Trade certificate/university degree | 17.4 | 12.0 | | 4.7 | 2.3 | |
| Missing | 0.9 | 1.0 | | 4.3 | 6.1 | |
| Area of residence (%) | | | <0.001 | | | <0.001 |
| Urban | 38.1 | 43.3 | | 40.2 | 39.8 | |
| Large town | 13.5 | 11.4 | | 11.6 | 14.1 | |
| Small town/remote area | 47.1 | 42.4 | | 46.6 | 42.6 | |
| Missing | 1.3 | 2.9 | | 1.6 | 3.6 | |
| Country of birth (%) | | | 0.001 | | | 0.003 |
| Australia | 74.6 | 70.9 | | 74.7 | 71.9 | |
| Other English-speaking | 14.0 | 12.9 | | 12.4 | 11.2 | |
| Non-English speaking | 7.9 | 12.1 | | 6.8 | 9.3 | |
| Missing | 3.5 | 4.1 | | 6.0 | 7.7 | |
| Depression (%) | | | 0.023 | | | <0.001 |
| No | 91.6 | 89.2 | | 94.3 | 87.6 | |
| Yes | 8.4 | 10.8 | | 3.4 | 7.6 | |
| Number of chronic diseases (%) | | | 0.037 | | | <0.001 |

**Table 1** ***(Continued)***

**Characteristics of respondents who reported stiff or painful joints 'never' or 'rarely' at Time 1**

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 55.8 | 52.6 | | 32.0 | 42.5 | |
| 1 | 31.0 | 30.5 | | 37.0 | 20.3 | |
| 2 | 9.7 | 11.8 | | 20.0 | 18.0 | |
| 3 | 2.7 | 3.7 | | 7.6 | 10.5 | |
| 4 or more | 0.8 | 1.4 | | 3.3 | 8.7 | |
| Smoking status (%) | | | <0.001 | | | 0.006 |
| Never | 55.4 | 54.8 | | 61.0 | 58.5 | |
| Former | 32.2 | 26.1 | | 27.6 | 26.8 | |
| Current | 12.2 | 18.3 | | 4.9 | 7.4 | |
| Missing | 0.2 | 0.8 | | 6.4 | 7.4 | |
| Body mass index (%) | | | <0.001 | | | <0.001 |
| <20 kg/m² | 5.1 | 5.9 | | 3.4 | 4.4 | |
| ≥ 20 and <25 kg/m² | 41.9 | 38.6 | | 48.4 | 46.1 | |
| ≥ 25 and <30 kg/m² | 28.0 | 26.3 | | 26.5 | 23.8 | |
| ≥ 30 kg/m² | 17.4 | 16.8 | | 9.7 | 9.1 | |
| Missing | 7.5 | 12.4 | | 12.0 | 16.6 | |
| Physical activity (%) | | | <0.001 | | | <0.001 |
| None (<40 MET.min/week) | 14.9 | 22.2 | | 24.4 | 40.1 | |
| Very low (40 to <300 MET.min/week) | 18.4 | 19.5 | | 14.0 | 14.2 | |
| Low (300 to <600 MET.min/week) | 18.0 | 15.6 | | 22.7 | 14.0 | |
| Moderate (600 to <1,200 MET.min/week) | 22.5 | 19.6 | | 15.8 | 12.2 | |
| High (1,200+ MET.min/week) | 26.2 | 23.1 | | 23.1 | 19.6 | |

MET, metabolic equivalent value. [a]Women were excluded if they did not provide data on physical activity at Time 1 or did not provide data on symptoms of stiff or painful joint at Time 2. The 243 mid-age women and 987 older women who were missing physical activity data are not included in the percentage of excluded respondents in each physical activity category. [b]*P* value is for the difference between women included and those excluded from the analysis.

### Descriptive characteristics of samples

The mid-age women were aged 48–55 years at T1. Most reported not completing 12 years of high school, reported living in a small rural town or remote area, reported being born in Australia, reported having one or no chronic diseases, reported not having a diagnosis of depression, and reported never having been a smoker. Almost one-half were overweight or obese (45.4%), and almost one-half (48.7%) met the national Australian physical activity guidelines by accruing 600 or more MET minutes of physical activity per week [34], which is equivalent to 150 minutes or more per week of moderate-intensity physical activity. Slightly more than one-third (36.4%) reported very low to low levels of physical activity (40–600 MET.min/week), which equates to 10–149 minutes per week of moderate-intensity physical activity. The remaining 14.9% were sedentary (<40 MET.min/week): they did not report even 10 minutes of moderate-intensity physical activity per week. At T2, 41.4% of the women reported 'never' having stiff or painful joints, 17.9% reported them 'rarely,' 30.8% reported them 'sometimes,' and 9.9% reported them 'often.'

The older women were aged 72–79 years at T1. As for the mid-age women, most reported not completing 12 years of high school, reported living in a small rural town or remote area, reported being born in Australia, reported not having a diagnosis of depression, reported having one or no chronic diseases, and reported never having been a smoker. Fewer older women (36.2%) than mid-age women were overweight or obese, and fewer were physically active. Less than one-half of the older women met the national physical activity guidelines (38.9%), and a similar percentage (38.7%) reported very low to low levels of physical activity. One-quarter (24.4%) of the older women were sedentary. At T2, 45.9% reported stiff or painful joints 'never', 12.2% reported them 'rarely,' 30.0% reported them 'sometimes,' and 11.8% reported them 'often.'

### Mid-age women

In univariate analysis, the odds of reporting stiff or painful joints 'sometimes or often' at T2 were significantly lower for mid-age women in the 'low' ($P = 0.011$), 'moderate' ($P = 0.043$), and 'high' ($P = 0.003$) physical activity categories at T1 than for those who were sedentary (see Table 2). The odds of reporting stiff or painful joints 'often' were significantly lower only for respondents in the 'moderate' physical activity category ($P = 0.032$). After adjusting for all variables that were significantly associated with stiff or painful joints in the univariate analyses, associations between physical activity and self-reported stiff or painful joints in the mid-age women were attenuated and no longer statistically significant ($P > 0.05$; see Table 2).

### Older women

In univariate analysis, older women in the 'moderate' ($P = 0.033$) and 'high' ($P = 0.040$) physical activity categories at T1 had significantly lower odds of reporting stiff or painful joints 'sometimes or often' at T2 than those in the 'none' category. Significantly lower odds of reporting stiff or painful joints 'often' were found for those in the 'low' ($P = 0.001$), 'moderate' ($P < 0.001$) and 'high' ($P < 0.001$) physical activity categories (see Table 3).

As was the case for the mid-age women, the association between physical activity and self-reported stiff or painful joints 'sometimes or often' was no longer statistically significant ($P = 0.252$) in the multivariable analysis in the older cohort. The odds for reporting stiff or painful joints 'often,' however, remained significantly lower for older women in the 'low' ($P = 0.024$), 'moderate' ($P < 0.001$) and 'high' ($P = 0.001$) physical activity categories than for those in the 'none' category (see Table 3).

## Discussion

Our aim was to explore the association between physical activity and the incidence of stiff or painful joints in cohorts of mid-age women and older women. Our main findings were that physical activity did not increase or decrease the odds of self-reported stiff or painful joints 'often' among the mid-age women; however, 'low,' 'moderate,' and 'high' levels of physical activity among the older women were associated with decreased odds of developing stiff or painful joints 'often' over 3 years, even after adjusting for confounding variables. This last finding indicates that, among older women who do not have or rarely have stiff or painful joints, participation in at least 75 minutes per week of moderate-intensity physical activity may be protective against complaints of 'often' having arthritis symptoms within the next 3 years. The results also suggest that engaging in at least 150 minutes of moderate-intensity physical activity per week, in accordance with the recommendations of the American College of Sports Medicine and the US Centers for Disease Control and Prevention [35], may be even more protective. These findings consequently indicate that public health and clinical advice for older women not currently experiencing stiff or painful joints should routinely include counseling on ways to be physically active to reduce their risk of developing stiff or painful joints.

Different findings between the two ALSWH cohorts with respect to the relationship between physical activity and stiff or painful joints 'often' were unexpected. One explanation is that occupational physical activity was not included in our assessment of physical activity and that many women in the mid-age cohort of the ALSWH were in paid work [36], whereas the older women were not. Failure to account for occupational physical activity may have resulted in greater misclassification of physical activity levels among the mid-age women than among the older women, which might explain the difference in findings between the two cohorts. Researchers who have used a crude measure of work-related physical activity have not, however, found a prospective association between occupational physical activity and arthritis in women

**Table 2**

**Association between risk factors and having stiff or painful joints among mid-age women ($n = 4,780$)**

| | Stiff or painful joints 'sometimes or often' | | Stiff or painful joints 'often' | |
|---|---|---|---|---|
| Variable at Time 1 | Unadjusted odds ratio (95% confidence interval) | Adjusted[a] odds ratio (95% confidence interval) | Unadjusted odds ratio (95% confidence interval) | Adjusted[a] odds ratio (95% confidence interval) |
| Education | | | | |
| Less than high school | 1.00 | 1.00 | 1.00 | 1.00 |
| Some high school | 0.77 (0.65–0.92) | 0.83 (0.69–0.99) | 0.55 (0.43–0.71) | 0.58 (0.45–0.75) |
| Completed high school | 0.73 (0.60–0.90) | 0.80 (0.65–0.99) | 0.50 (0.37–0.68) | 0.55 (0.40–0.76) |
| Trade certificate/ university degree | 0.64 (0.52–0.78) | 0.70 (0.56–0.87) | 0.49 (0.35–0.67) | 0.55 (0.39–0.77) |
| Missing | 0.97 (0.51–1.82) | 0.92 (0.48–1.75) | 1.51 (0.70–3.26) | 1.30 (0.58–2.93) |
| Area of residence | | | | |
| Urban | 1.0 | 1.0 | 1.0 | 1.0 |
| Large town | 0.87 (0.73–1.05) | 0.87 (0.72–1.05) | 0.8 (0.58–1.11) | 0.77 (0.55–1.07) |
| Small town/remote area | 1.11 (0.98–1.26) | 1.09 (0.96–1.24) | 1.14 (0.93–1.39) | 1.08 (0.88–1.34) |
| Missing | 0.83 (0.49–1.40) | 0.83 (0.49–1.42) | 0.3 (0.75–1.28) | 0.32 (0.76–1.33) |
| Country of birth | | | | |
| Australia | 1.00 | 1.00 | 1.00 | 1.00 |
| Other English-speaking | 1.07 (0.91–1.27) | 1.12 (0.95–1.33) | 0.70 (0.51–0.95) | 0.70 (0.51–0.97) |
| Non-English speaking | 0.97 (0.78–1.21) | 1.02 (0.82–1.28) | 0.96 (0.67–1.36) | 0.99 (0.69–1.43) |
| Missing | 1.35 (0.99–1.84) | 1.36 (0.99–1.88) | 1.64 (1.06–2.53) | 1.61 (1.02–2.53) |
| Depression | | | | |
| No | 1.00 | 1.00 | 1.00 | 1.00 |
| Yes | 1.56 (1.29–1.94) | 1.44 (1.17–1.78) | 2.10 (1.60–2.77) | 1.76 (1.32–2.35) |
| Number of chronic diseases | | | | |
| 0 | 1.00 | 1.00 | 1.00 | 1.00 |