Balancing training is the most efficacious exercise to prevent falls. This study examined the associations between common sporting activities and the incidence of falls, and whether lower risks can be attributed to the superior balance of sports participants. We studied a population-based cohort of 1,667 older Australian men (mean age = 76.8 years) in the Concord Health and Ageing in Men Project (CHAMP) between 2005 and 2011. Data on incident falls were captured by 12 triannual telephone call cycles per participant and were analyzed using negative binomial regression. The length of follow-up averaged 43.8 months (median, 48 months), during which time 2,662 falls were recorded. In unadjusted models, golfers (n = 160; incidence rate ratio (IRR) = 0.65, 95% confidence interval (CI): 0.47, 0.89) and swimmers (n = 88; IRR = 0.47, 95% CI: 0.30, 0.71) had significantly lower risks of falling. After adjustment for leisure-time physical activity, walking, lifestyle physical activity score (e.g., chores, gardening), and conventional risk factors for falling, swimming was the only activity that was associated with a protective effect (IRR = 0.67, 95% CI: 0.45, 1.00). Swimmers had significantly lower postural sway (β = −5.23 cm², P < 0.05) and shorter time to complete a narrow walk test than men who took part in only lifestyle physical activities. Balance indicators were strong predictors of the incidence of falls. The IRR for swimmers was 0.71 (95% CI: 0.48, 1.06) after adding balance measures to the adjusted model.

Aged; balance; follow-up studies; gait; incident falls; men; sports

Abbreviations: CHAMP, Concord Health and Ageing in Men Project; CI, confidence interval; IRR, incidence rate ratio; LTPA, leisure-time physical activity; PASE, Physical Activity Scale for the Elderly.
the risk of falling may vary across different domains of physical activity (i.e., leisure-time activity or housework), and that the risk differs according to sex and functional status (i.e., effect modification) (17, 18). In 1 study, the total amount of LTPA was associated with a higher risk of falling in older adults whose functional status was classified as high (18). However, there was no attempt to isolate the effect of specific types of LTPA or sports.

The rationale for examining specific types of LTPA is drawn from the sports science discipline, which has found that different types of sports offer different degrees of balance challenge (19). For example, studies of postural sway in participants in a wide range of sporting activities indicate that gymnasts have superior balance abilities compared with participants in other sports; swimmers have better balance than surfers; and dancers have better balance than other athletes (e.g., cyclists, runners, basketball players). However, all sports participants performed better on tests of balance than age-matched nonparticipants (19, 20).

The aims of this research were 1) to identify associations between common types of LTPA among older men and the incidence of falls over 4 years, and 2) to determine if any observed association is mediated by static or dynamic balance, mobility, or gait speed.

METHODS

Participants

The data analyzed in this study came from the Concord Health and Ageing in Men Project (CHAMP), a cohort study of men aged 70 years and older living in inner suburban Sydney, Australia (21). Participants were recruited from the electoral roll, and because voting is compulsory in Australia, this provided a representative sample of the population. The only exclusion criterion was living in a residential aged care facility. The CHAMP was approved by the Concord Hospital’s human research ethics committee, and all participants gave informed consent.

Of the 2,815 eligible men we contacted, 1,511 (54%) participated in the study. An additional 194 men living in the study area heard about the study from friends or local media and were recruited before they received invitation letters, resulting in a final baseline sample of 1,705 men. Baseline data were collected between January 28, 2005, and June 4, 2007. The cohort profile and detailed baseline measurements are described elsewhere (21).

Physical activity

We used the validated, self-administered Physical Activity Scale for the Elderly (PASE) questionnaire (22, 23). Participants reported the number of times in the past 7 days that they walked outside and did light, moderate, or strenuous sports and muscle strengthening, as well as the duration they spent in each activity. For each LTPA question, participants were asked to list, in written format, the exact activity type they did. The written answers were used to classify participants according to activity types (e.g., yes or no for participation in golf). A total of 98% of questions were answered for light sports, 93% for strenuous sports and muscle strengthening, and 83% for moderate sports. Because 2 or more activities can be reported in response to the same question (e.g., swimming and dancing were both listed as moderate-intensity sports) (16), and 13.5% of participants reported participating in more than 1 sport, we could not compute the specific time spent on each sport, but we could calculate the score for each question, which is the time spent on the activity during a week, weighted for intensity level (22). PASE questions also asked about functional activities, such as light housework, heavy housework, home repair, lawn and yard care, outdoor gardening, caregiving, and paid or volunteer work, hereafter referred to as “lifestyle physical activities”; these were summed and assigned a weighted PASE score (22).

Falls ascertainment

All study participants were telephoned at 4-month intervals after their baseline assessments and asked whether they had fallen in the preceding 4 months and, if so, how many times they had fallen. For the present study, up to 12 triannual telephone call cycles were used (with the last calls occurring on May 24, 2011).

Covariates

Age, place of birth (Australia, other English-speaking country, or non–English-speaking country), years of education, and living arrangement (living alone vs. other) were tested as confounders. These sociodemographic characteristics were found to be associated with the incidence of falls in the same cohort (24). History of falling was ascertained at baseline by asking whether participants had fallen in the past 12 months and, if so, the number of falls they had. Responses were categorized as no falls, 1 fall, or 2 or more falls. Self-rated health was determined by the question, “Compared to other people your own age, how would you rate your overall health?” (25). Participants were dichotomized as those who perceived their health as very poor, poor, or fair versus those who perceived their health as good or excellent. Participants were asked about their use of prescription medications and were grouped into 2 categories: those who used fewer than 4 medications and those who used 4 or more medications. Men were also categorized according to their use of psychoactive drugs on the basis of the Iowa Drug Information System (26). Depressive symptoms were measured using the short version of the Geriatric Depression Scale (27). We defined clinical depression as having 5 or more depressive symptoms. Disability was measured using the Katz Index of Independence in Activities of Daily Living Scale (28). Corrected visual acuity was assessed using a Bailey-Lovie chart (29). Participants with visual acuity of 20/40 or worse were considered to have poor vision. During the baseline visits, participants were screened for cognitive impairment; those who scored 26 points or lower on the Mini–Mental State Examination (30) and who had a score higher than 3.6 on the Informant Questionnaire on Cognitive Decline in the Elderly (31) underwent further assessment by a geriatrician. Participants were then categorized as having normal cognition, mild cognitive impairment, or dementia.
Participants were asked whether they had ever been told by a health professional that they had diabetes, thyroid disease, osteoporosis, Paget’s disease, stroke, Parkinson’s disease, kidney stones, epilepsy, fits, high blood pressure, heart attack, myocardial infarction, angina, congestive heart failure, intermittent claudication, chronic obstructive disease, liver disease, chronic renal disease, renal failure, arthritis, gout, or cancer. The number of reported comorbidities were summed, excluding Parkinson’s disease, stroke, and arthritis, and this was dichotomized at the upper quartile (<3 vs. ≥3 comorbidities). Parkinson’s disease, stroke, and arthritis were each examined separately.

Physical performance

Gait speed was measured on a 6-meter course at the participant’s usual walking pace. The fastest speed (in m/second) of 2 trials was recorded. The narrow walk test was used as an indirect measure of dynamic balance. Participants were asked to walk a 6-meter course while keeping each foot within a lane that was 20 cm wide. A trial was considered successful if the participant had no more than 2 deviations from the lane. Participants were asked to complete 2 trials and were given the option of a third trial if they were unsuccessful in the first two. We analyzed the fastest time (in seconds) from any successfully completed trial (17). Static balance was assessed by postural sway on a compliant surface using a sway meter with a pen attached to its end that measures displacements of the body at waist level (32). Participants were asked to stand as still as possible for 30 seconds with their eyes open on a medium-density foam rubber mat (15 cm thick). The area of sway was calculated as the total number of 1-mm² grid sections traversed by the pen anteroposteriorly and mediolaterally divided by 100 to express the score in cm². Five consecutive sit-to-stand tasks without the use of arms were timed (in seconds). Participants who did not complete the performance tests because of physical inability were assigned scores that were 2.5 standard deviations worse than the cohort mean.

Statistical analyses

The analytical sample for this study comprises 1,667 participants who completed the PASE questionnaire (n = 1,673) and had valid data on falls (n = 1,688). No falls data were available for 12 men because of death or loss to follow-up before the first follow-up call; an additional 6 men were excluded because they were outliers (i.e., they reported more than 100 falls in a cycle). We first examined the most common recreational and sports activities and the number of LTPAs in which participants took part, including combinations of activity types. The most common activities were golf (n = 160), calisthenics (i.e., class- or home-based exercise, n = 156), lawn bowls (n = 130), use of aerobic exercise machines (e.g., stationary bicycle, treadmill, n = 91), swimming (n = 88), muscle strengthening (n = 74), fishing (n = 56), dancing (n = 49), tennis (n = 47), cycling (n = 46), and sailing (n = 27). Other activities, such as jogging, tai chi, yoga, and rowing, were reported by 10 or fewer participants. We calculated the unadjusted falls incidence rate ratio (IRR) for the most common (i.e., reported by ≥5% of participants) types of sport as a yes/no variable using negative binomial regression, which enables adjustment for different follow-up lengths and the analysis of recurrent events that are not independent of one another (33). We then ran a single model with activities performed by at least 27 participants and adjusted for age and PASE subscores for walking; light, moderate, or strenuous sports; muscle strengthening; and lifestyle physical activities. Participants who did not indicate a sport type were coded as not doing the activity but were included if they had valid data to calculate LTPA scores (i.e., number of times and duration). Excluded from the model were 28 (1.7%) men with missing data in 1 of the PASE components (n = 1,639). In a second model, we examined the IRR adjusted for the above factors, plus established risk factors for falls (i.e., history of falling, dementia, stroke, Parkinson’s disease, arthritis, other comorbidities, poor visual acuity, number of medications used, use of psychoactive medication, and score on the Activities of Daily Living scale), perceived health status, and sociodemographic confounders. The fully adjusted model comprises 1,537 men who had no missing data on any covariates.

We also conducted subgroup analyses (including tests for interaction) according to history of falling, comorbidities, and self-rated health to assess the possibility that the observed association might be the result of better health status of sports participants. General linear models were used to compare the baseline performances on all physical measures by common types of LTPA, adjusting for the above risk factors for falling. Excluded from these analyses were 151 men who had missing values on any 1 of these tests (exclusions included 35 men for gait speed, 98 for narrow walk, 49 for postural sway, and 29 for the sit-to-stand test). When participants in a particular sport or activity (i.e., golf, calisthenics, lawn bowls, aerobic exercise machines, muscle strengthening, or swimming) performed significantly better on a test, we considered that sport or activity to be a possible mediator that protected the participants from falling.

RESULTS

Walking for exercise or errands was reported by 84% of the sample, and 42% reported some type of LTPA; of those, 60% (n = 427) reported 1 type, 24% (n = 170) reported 2 types, and 16% reported 3 or more types of LTPA. Almost all LTPA participants (98%) also walked and engaged in lifestyle physical activities.

Table 1 presents the characteristics of the sample and participants in the 5 most common types of LTPA by health and sociodemographic characteristics and physical activity patterns. Golfers were more likely to be born in Australia and to have 10 or more years of education than other men. Swimmers included the highest proportion of participants living alone. In terms of risk profiles for falling, golfers and swimmers were similar: they were younger, had a lower proportion of recurrent fallers in the previous year, had fewer limitations in activities of daily life, had fewer comorbidities, had fewer depressive symptoms, were less likely to use psychoactive drugs, and were less likely to rate their health as fair or poor compared with those who participated in lawn bowls.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total Sample $(n=1,667)$</th>
<th>Golf $(n=160)$</th>
<th>Calisthenics$^b$ $(n=152)$</th>
<th>Lawn Bowls $(n=130)$</th>
<th>Use of Aerobic Exercise Machines $(n=91)$</th>
<th>Swimming $(n=88)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>76.8 (5.4)</td>
<td>75.2 (4.6)</td>
<td>77.6 (5.9)</td>
<td>77.1 (5.4)</td>
<td>76.7 (6.0)</td>
<td>75.7 (4.6)</td>
</tr>
<tr>
<td>Falls history, no. of falls</td>
<td>81.3 90.6 75.5 84.4 82.1 82.9</td>
<td>10.5 5.6 13.5 10.1 7.9 13.6</td>
<td>8.3 3.7 11.0 5.4 10.1 3.4</td>
<td>7.7 3.7 9.6 5.2 7.4 3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive status</td>
<td>76.8 94.4 89.2 93.8 89.0 93.2</td>
<td>7.1 3.8 3.2 3.8 6.6 3.4</td>
<td>6.1 1.9 7.6 2.3 4.4 3.4</td>
<td>46.2 46.2 50.6 55.4 52.7 53.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parkinson's disease, stroke, or arthritis</td>
<td>29.9 20.0 30.1 23.8 35.1 22.7</td>
<td>4.4 1.3 4.5 0.8 2.2 1.1</td>
<td>14.3 6.3 15.8 5.4 11.0 4.5</td>
<td>37.6 25.8 36.3 36.2 41.7 35.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥3 Comorbidities</td>
<td>29.9 20.0 30.1 23.8 35.1 22.7</td>
<td>4.4 1.3 4.5 0.8 2.2 1.1</td>
<td>14.3 6.3 15.8 5.4 11.0 4.5</td>
<td>37.6 25.8 36.3 36.2 41.7 35.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place of birth</td>
<td>50.0 83.7 57.1 66.9 64.8 48.9</td>
<td>6.2 3.8 4.5 4.6 7.7 11.3</td>
<td>43.8 12.5 38.5 28.5 27.5 39.8</td>
<td>18.6 17.5 19.6 17.7 18.7 21.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living alone</td>
<td>18.6 17.5 19.6 17.7 18.7 21.6</td>
<td>15.2 11.2 10.9 7.3 7.6 7.0</td>
<td>46.2 46.2 50.6 55.4 52.7 53.4</td>
<td>29.7 20.0 27.2 27.3 24.2 22.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participant in the activity</td>
<td>9.5 9.4 7.7 5.4 5.2</td>
<td>13.5 54.4 58.7 58.5 59.3 59.9</td>
<td>13.5 54.4 58.7 58.5 59.3 59.9</td>
<td>13.5 54.4 58.7 58.5 59.3 59.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participant in ≥2 LTPAs</td>
<td>9.5 9.4 7.7 5.4 5.2</td>
<td>13.5 54.4 58.7 58.5 59.3 59.9</td>
<td>13.5 54.4 58.7 58.5 59.3 59.9</td>
<td>13.5 54.4 58.7 58.5 59.3 59.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LTPA, hours/week</td>
<td>0.40 (0.76) 1.41 (1.13) 0.84 (0.97) 1.19 (0.97) 1.00 (1.10) 1.07 (1.15)</td>
<td>1.07 (1.15)</td>
<td>0.85 (0.92) 1.06 (1.03) 0.84 (0.89) 0.78 (0.94) 0.74 (0.92) 1.29 (1.21)</td>
<td>92 (46.7) 99.8 (41.9) 87.4 (45.0) 91.3 (44.3) 83.0 (45.1) 96.4 (45.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking, hours/week</td>
<td>0.85 (0.92) 1.06 (1.03) 0.84 (0.89) 0.78 (0.94) 0.74 (0.92) 1.29 (1.21)</td>
<td>92 (46.7) 99.8 (41.9) 87.4 (45.0) 91.3 (44.3) 83.0 (45.1) 96.4 (45.6)</td>
<td>92 (46.7) 99.8 (41.9) 87.4 (45.0) 91.3 (44.3) 83.0 (45.1) 96.4 (45.6)</td>
<td>92 (46.7) 99.8 (41.9) 87.4 (45.0) 91.3 (44.3) 83.0 (45.1) 96.4 (45.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifestyle physical activity score$^e$</td>
<td>125 (62.2) 162 (58.4) 130 (60.3) 136 (61.0) 132 (60.0) 155 (71.8)</td>
<td>125 (62.2) 162 (58.4) 130 (60.3) 136 (61.0) 132 (60.0) 155 (71.8)</td>
<td>125 (62.2) 162 (58.4) 130 (60.3) 136 (61.0) 132 (60.0) 155 (71.8)</td>
<td>125 (62.2) 162 (58.4) 130 (60.3) 136 (61.0) 132 (60.0) 155 (71.8)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ADL, activity of daily living; LTPA, leisure-time physical activity; PASE, Physical Activity Scale for the Elderly; SD, standard deviation.

$^a$ Categories are not mutually exclusive.

$^b$ Includes calisthenics, exercise classes, and light exercise at home.

$^c$ Corrected visual acuity was assessed using a Bailey-Lovie chart (29). Visual acuity of >20/40 was considered “good,” and visual acuity of ≤20/40 was considered “poor.”

$^d$ Depressive symptoms were measured using the short version of the Geriatric Depression Scale (27).

$^e$ Includes functional activities, such as light housework, heavy housework, lawn and yard care, caregiving, and paid or volunteer work.
or calisthenics and those who used aerobic exercise machines. Golfers and swimmers had the highest total PASE scores. Golfers reported the most weekly time spent in LTAPAs, whereas swimmers reported the most time spent walking.

Follow-up ranged from 4 to 48 months with a mean of 43.1 months and median of 48 months. During this period, we recorded 2,662 falls. The incidence rate of falls for this cohort was 0.44 falls per person-year. The falls data, by the most common types of LTPA, are presented in Table 2. The unadjusted IRRs for falls were significantly lower for swimmers (IRR = 0.47, 95% CI: 0.30, 0.71) and golfers (IRR = 0.65, 95% CI: 0.47, 0.89) but not for participants in other prevalent LTAPAs. After accounting for time spent walking, PASE scores for light, moderate, and strenuous sports; muscle strengthening; lifestyle physical activity scores; and risk factors for falling, the association between swimming and falling was attenuated but remained significant (IRR = 0.67, 95% CI: 0.45, 1.00).

There was no association between golf and falling after adjustment for physical activity and risk factors for falling. Associations between swimming and incident falls were similar in subgroups defined by history of falling, comorbidities, and perceived health status (all P for interaction > 0.05).

To isolate the effect of swimming, we conducted exploratory analysis and grouped participants as follows: 1) those who swim only, with or without walking/lifestyle physical activities (n = 36); 2) those who swim and do 1 or more other LTAPAs, with or without walking/lifestyle physical activities (n = 52); 3) those who do not swim but who do other LTAPAs (n = 620); 4) those who walk only and do no LTAPAs (n = 796); and 5) those who do lifestyle physical activities only (n = 169). The IRRs differed slightly between those who swim only (IRR = 0.52, 95% CI: 0.28, 0.96) and those who swam in combination with other LTAPAs (IRR = 0.56, 95% CI: 0.32, 0.99) compared with men who engaged only in lifestyle physical activities.

Table 3 presents the β coefficients of the 4 physical performance tests at baseline by the categories described above, adjusted for physical activity and risk factors for falling. Postural sway on a foam surface was significantly lower (−5.23 cm²; P = 0.027) for “only swimmers.” Swimmers who engaged in other LTAPAs had the fastest time on the narrow walk test (−1.26 seconds, P = 0.014), as well as when the group of “swimmers only” and the group of “swimmers who did other LTPA” were combined (data not shown, −1.00 second, P = 0.017). In the sit-to-stand test, swimmers were faster than other groups but not significantly so (P = 0.100). Gait speed was significantly faster only for participants in other LTAPAs.

Postural sway was a strong predictor of falls incidence; compared with those in the lowest quartile of postural sway (best results), the crude IRRs were 24% higher for those in the 2nd quartile, 40% higher for those in the 3rd quartile, and 76% higher for those in the 4th quartile. Similarly, the crude IRRs for falls declined with faster narrow walk speed quartiles (43% for quartile 2, 59% for quartile 3, and 69% for quartile 4). After adding postural sway and narrow walk data to the model that adjusted for all other risk factors, the IRR between swimming and falls changed from 0.67 to 0.71 and was not statistically significant (95% CI: 0.48, 1.06).

**DISCUSSION**

To the best of our knowledge, this is the first study to compare the incidence rates of falling among older people by common types of sports participation. We found that swimming was the only sport associated with a substantially lower risk of falling. The results suggest that the possible benefits of swimming in reducing falls may be due in part to the effect of swimming on the swimmer’s balance.

The lower incidence of falls (32%) that was associated with swimming is close to the pooled effect size (38%) of fall prevention programs that have included highly challenging balance exercise of sufficient dose in randomized controlled trials of falls prevention (10). Subgroup analyses showed that the apparent protective effect of swimming did not differ by baseline risk of falling or self-reported health status. Previous epidemiologic studies have aggregated all
Table 3. Differences in Scores on Baseline Physical Tests Stratified by Physical Activity Participation From General Linear Models*, the Concord Health and Ageing in Men Project, Australia, 2005–2011

<table>
<thead>
<tr>
<th>Physical Activity Group</th>
<th>No. of Subjects</th>
<th>Postural Sway Area, cm² (β (SE))</th>
<th>Narrow Walk, seconds (β (SE))</th>
<th>Seconds to Complete 5 Sit-to-Stands (β (SE))</th>
<th>Walking Speed, m/second (β (SE))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifestyle activities only</td>
<td>130</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>Swimming only</td>
<td>33</td>
<td>−5.23 (2.39)*</td>
<td>−0.71 (0.53)</td>
<td>−1.49 (1.18)</td>
<td>0.041 (0.04)</td>
</tr>
<tr>
<td>Swimming and LTPAs</td>
<td>47</td>
<td>−0.57 (2.27)</td>
<td>−1.26 (0.51)*</td>
<td>−0.42 (1.12)</td>
<td>0.041 (0.03)</td>
</tr>
<tr>
<td>Other LTPA†</td>
<td>543</td>
<td>0.16 (1.34)</td>
<td>−0.74 (0.30)*</td>
<td>−0.87 (0.66)</td>
<td>0.052 (0.02)*</td>
</tr>
<tr>
<td>Walking and no LTPAs</td>
<td>656</td>
<td>0.12 (1.21)</td>
<td>−0.29 (0.27)</td>
<td>−0.57 (0.60)</td>
<td>0.027 (0.02)</td>
</tr>
</tbody>
</table>

Abbreviations: LTPA, leisure-time physical activity; PASE, Physical Activity Scale for the Elderly; SE, standard error.

* Models are adjusted for hours of walking; PASE scores for light-intensity LTPA, moderate-intensity LTPA, strenuous LTPA, and muscle strengthening; lifestyle physical activity score; country of birth (Australia, other English-speaking country, or non–English-speaking country); living alone (yes/no); years of education (<10 or ≥10 years); self-rated health (good or excellent vs. fair or poor); falls history (no falls, 1 fall, ≥2 falls); cognitive status (normal cognition, mild cognitive decline, or dementia); depression (≥5 symptoms on the short version of the Geriatric Depression Scale); disability in activities of daily life (≥1 disability on the Activities of Daily Living scale); medication use (>4 medications); Parkinson’s disease (yes/no); stroke (yes/no); arthritis (yes/no); other comorbidities (≥3 chronic conditions); use of psychoactive drugs (yes/no); and visual acuity (good visual acuity, >20/40 vs. poor visual acuity, ≤20/40), excluding those with missing data on number of times or duration of any of the PASE questions, risk factors for falling (n = 131), or any physiological test (n = 151).

† Static balance was assessed by postural sway on a compliant surface using a sway meter with a pen attached to its end that measures displacements of the body at a waist level (32). Participants were asked to stand as still as possible for 30 seconds with their eyes open on a medium-density foam rubber mat (15 cm thick). The area of sway was calculated as the total number of 1-mm² grid sections traversed by the pen anteroposteriorly and mediolaterally divided by 100 to express the score in cm². Participants were asked to walk a 6-meter course while keeping each foot within a lane that was 20 cm wide. A trial was considered successful if the participant had no more than 2 deviations from the lane.

§ Five consecutive sit-to-stand tasks without the use of arms. Participants who did not complete the performance tests because of physical inability were assigned scores that were 2.5 standard deviations worse than the cohort mean.

P < 0.05.

† LTPAs that are not golf, calisthenics, lawn bowls, muscle strengthening, or swimming.

Types of LTPA and categorized participants according to the level of intensity of the activities in which they participated (e.g., light, moderate, or vigorous) or the amount of physical activity. The results of such a quantitative approach are conflicting; in 1 systematic review, a U-shaped association with falls incidence or no association was reported (34), whereas other studies found protective associations (35, 36). We hypothesize that, in addition to the amount of physical activity, LTPA types will have different effects according to the physiological challenges they provide for older adults’ neuromotor systems (e.g., coordination, reaction time, and balance), which is an idea that has been scarcely researched (14, 37).

To date, few studies have examined differences in neuromotor capabilities in older populations using cross-sectional observations; long-term social dancers had better balance and gait characteristics than their age-matched controls (38, 39), and the postural sway of long-term older ice skaters was similar to that of young adults, suggesting that this sport counteracts age-related changes in balance control (40).

Balance control relies on rapid and continuous feedback from visual, vestibular, and sensory systems to execute smooth and coordinated neuromuscular actions (39). Swimmers are fundamentally different from other weight-bearing activities (19). Swimmers must maintain a horizontal body position in the water to avoid drag by using their core muscles (e.g., erector spinae, rectus abdominis, and iliopsoas). It is possible that the nature of swimming leads to improved core muscle strength, which could have resulted in less destabilizing motion on postural sway tests in the current study. This is in line with the hypothesis that balance abilities are sport-specific. For example, studies have found that shooters have minimal sway in the bipedal balance test with their eyes open (which mimics the normal shooting position), and ballet dancers have excellent balance in a unilateral stance with their eyes open but not with their eyes closed when compared with participants in other sports (41), suggesting heavy reliance on vision to maintain balance (19, 42).

Another possible neuromuscular benefit of swimming is the need to use foot movements of various styles, which may improve the force of ankle dorsiflexion. Support for this explanation comes from the only study of older people to date that has examined neuromotor control as it relates to swimming (43). In Taiwan, 20 subjects with a mean age of 65 (standard deviation, 5.5) years who swam regularly were compared with 34 active (jogging, mountain climbing) non-swimmers with a mean age of 67 (standard deviation, 5.7)
years. In balance testing, swimmers had significantly better results only in the 2 complicated balance conditions that require somatosensory feedback from the ankles and feet a) with eyes closed and fixed support and b) with eyes open and unfixed support (i.e., creating a conflict with vestibular inputs). Ankle strength and force are considered components of balance control (44), but they were not measured at baseline in CHAMP subjects.

A strength of this study is the representativeness of our sample. Our estimates of sports participation were similar to those reported by the Australian Sport Commission’s Exercise, Recreation, and Sport Survey for older populations (11). In this survey, 6% of older Australian men reported swimming in the past 12 months compared with 5% in the CHAMP. Golf and lawn bowls were the second most prevalent sports, with 12% and 10% participation rates, respectively, over a 12-month period. Furthermore, the health profile of CHAMP participants resembles that of older men who participated in the nationally representative Men in Australia Telephone Survey (45). Additional strengths are the high follow-up rate (98%) and the comprehensive baseline measurements in the CHAMP that enabled us to control for a large number of risk factors for falling.

PASE is one of the most extensively used physical activity questionnaires in aging research (46), but there are several limitations in our measures of sports participation that must be acknowledged. First, we were unable to test the effect of each activity’s “dose.” Second, 1-week recall may not accurately reflect habits during a 4-year follow-up period. Hence, we were unable to separate long-term swimmers from novice or occasional swimmers. Duration of participation in sports activity is a determinant of balance abilities (19, 20). Here, superior performance on the postural sway test was noted for the “swimming only” group and less so for those who swam and did other LPTA. This may suggest that this group consists of long-term swimmers who have achieved a balance advantage, but we could not corroborate this from the data collected by the PASE questionnaire. Last, because of missing answers regarding for sport type, we may have underestimated the number of participants in each sport.

Another major limitation is the triannual, as opposed to monthly, assessment of falls, which may have led to underestimation of falls. However, there is no reason to believe that there was differential underestimation by type of LTPA; furthermore, underestimation would only have biased our estimates toward the null. In an observational study, selection bias cannot be ruled out; we found that men who chose to swim in old age were generally healthier than men who chose to participate in other activities. The exception was golfers, who had a similar health profile to swimmers. The fact that golf was not associated with a lower risk of falling supports the existence of a causal link between swimming and a lower risk of falling. Furthermore, the association between swimming and falling remained strong after adjustment for multiple confounders, and the association was also evident in subgroups of men defined by health status and history of falling. Yet, despite the wide range of physiological tests in the CHAMP, we were unable to fully explain the mechanism by which swimming might protect against falling. After adjustment for balance tests, the association was only slightly attenuated, suggesting that other, unmeasured factors contributed to the observed protective association.

In conclusion, our study suggests that swimming may prevent falls. Randomized trials of swimming for falls prevention appear warranted. Further research is required to determine whether swimming is associated with lower incidence of fractures. Swimming is generally considered to be of little value for fracture prevention because it is not a weight-bearing exercise and so does not affect bone density (47), but swimming could reduce fracture risk by preventing falls.

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