Associations of the 'weekend warrior' physical activity pattern with mild dementia: findings from the Mexico City Prospective Study

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ABSTRACT

Objectives To investigate associations of the 'weekend warrior' physical activity pattern with mild dementia.

Methods Participants in the Mexico City Prospective Study were surveyed from 1998 to 2004 and re-surveyed from 2015 to 2019. Participants were asked about leisure time physical activity at baseline. Those who exercised up to once or twice per week were termed 'weekend warriors' and those who exercised more often were termed 'regularly active'. A Mini Mental State Examination (MMSE) was used to assess mild dementia at re-survey. Cox models were adjusted for age, sex, education, income, blood pressure, smoking, body mass index, civil status, sleep, diet and alcohol at baseline. The attributable fraction was defined as the proportion of cases that would not exist if all adults were to exercise once or twice per week or more often.

Results The analysis included 10 033 adults of mean (SD) age 51 (10) years followed for 16 (2) years. There were 2400 cases when mild dementia was defined as a score of ≤22 on the MMSE. Compared with the group that reported no sport or exercise, the hazard ratio was 0.75 (95% CI 0.61 to 0.91) in the weekend warrior group, 0.89 (95% CI 0.78 to 1.02) in the regularly active group and 0.84 (95% CI 0.75 to 0.95) in the combined group. The attributable fraction was 13% (95% CI 5% to 21%). Similar results were observed when mild dementia was defined as a score of ≤23 on the MMSE.

Conclusions This longitudinal analysis suggests that the weekend warrior physical activity pattern is associated with a reduced risk of mild dementia.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Prospective cohort studies in Africa, East Asia and Pacific, Europe and North America suggest that leisure time physical activity is a major modifiable risk factor for cognitive decline and dementia. However, there are no such studies in Latin America.

WHAT THIS STUDY ADDS

⇒ The 'weekend warrior' physical activity pattern may be a more convenient option for busy people around the world. In this prospective cohort study, the risk of mild dementia was reduced by an average of 15% in the 'weekend warriors' who exercised once or twice per week and by 10% in the 'regularly active' who exercised more often when mild dementia was defined as a score of ≤22 on the Mini Mental State Examination.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ To the best of our knowledge, this is the first prospective cohort study to show that the weekend warrior physical activity pattern and the regularly active physical activity pattern are associated with similar reductions in the risk of mild dementia.

⇒ This study is important because it suggests that even busy people can gain cognitive health benefits from taking part in one or two sessions of sport and exercise per week.

INTRODUCTION

The number of people living with dementia is predicted to increase from around 57 million cases globally in 2019 to around 153 million cases in 2050.[1] The proportion of people living with the condition is predicted to increase by around 75% in the UK and other countries in Western Europe and by around 200% in Mexico and other countries in Latin America.[1] Cognitive impairment often leads to dementia and it is important to identify modifiable risk factors because a 5-year delay in onset might halve the prevalence of dementia.[2] However, nearly all the evidence about potentially modifiable risk factors for cognitive impairment comes from studies in high-income countries.[3] Indeed, the authors of the 2020 Lancet Commission on Dementia Prevention, Intervention, and Care concluded that there was an urgent need for more evidence from Latin America.[3] Prospective cohort studies suggest that leisure time physical activity is a major modifiable risk factor for cognitive decline and dementia.[4] However, to the best of our knowledge, there are no such studies in Latin America. The 'weekend warrior' takes part in one or two sessions of sport or exercise per week,[5] and it may be particularly important to investigate the benefits of the weekend warrior physical activity pattern in Latin America because lack of time is a major barrier to leisure time physical activity in the region.[6–8] Therefore, the main objective of the present analysis was to investigate associations of the weekend warrior physical activity pattern with mild dementia in the Mexico City Prospective Study. Katzmarzyk

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and colleagues estimated that the burden of dementia attributable to low physical activity was approximately 10% in high-income Western countries and 11% in Latin America and the Caribbean.[9] They also calculated that the burden of dementia attributable to low physical activity was approximately 8.5% in Mexico.[9] However, Katzmarzyk and colleagues[9] used data from outside Mexico to estimate dementia risks.[4] Therefore, the secondary objective of the present analysis was to investigate the burden of mild dementia attributable to low leisure time physical activity in Mexico City.

METHODS

Participants

The Mexico City Prospective Study is described in detail elsewhere.[10] Briefly, door-to-door interviews were conducted from 1995 to 1997 to compile a record of all households in the neighbouring districts of Coyoacán and Iztapalapa in Mexico City in Mexico.[10] Recruitment teams then visited households and at least one participant aged 35 years or older was recruited from 94% of eligible households.[10] The resulting sample was deemed to be broadly representative of the population aged 35 years or older in Mexico City.[10] The baseline survey took place from 1998 to 2004, the re-survey took place from 2015 to 2019, and mortality was tracked to 31 December 2020. The present analysis only includes cohort members who took part in the baseline survey and the re-survey. Trained nurses collected data in the participant's household and all participants provided written informed consent. The data used in the current report were obtained through an open-access data request made to the Mexico City Prospective Study principal investigators.

Exposure

The exposure was leisure time physical activity, which is a broad term that includes sport and exercise.[11–13] During the baseline survey, participants were asked whether they exercised or played sports (yes or no). Those who said 'yes' were then asked how many times per week they exercised (less than once per week; once or twice per week; or three or more times per week). Finally, they were asked how many minutes they spent exercising per session (<30; 30–60; or >60). Four exposure groups were created based on the physical activity questions. The 'no sport or exercise' group included those who said they did not exercise or play sports. The 'weekend warrior' group included those who said they exercised or played sports up to once or twice per week. The 'regularly active' group included those who said they exercised or played sports three or more times per week. We have shown that physical activity patterns can change considerably between baseline and re-survey in participants in the Mexico City Prospective Study.[14] Therefore, we also included a combined group of weekend warriors and the regularly active. Simple physical activity assessment tools like the one used in the present study have been validated against multiple-item physical activity assessment tools[15] and against cardiorespiratory fitness.[16] The terms 'sport' and 'exercise' can have negative connotations in the UK and other Western countries,[17] but asking someone what sport they like in Latin America is as innocent a question as asking them what music they like.[8]

Outcome

The Mini Mental State Examination (MMSE) is probably the most widely used tool to screen for cognitive impairment and dementia in older adults.[18] It has a sensitivity of 0.89 (95% CI 0.85 to 0.92) and a specificity of 0.89 (95% CI 0.85 to 0.93).[18] The original MMSE[19] and the Spanish version used in the present study have the same domains and scores: orientation to time (5 points); orientation to place (5 points); registration (3 points); attention and calculation (5 points); recall (3 points); and language (9 points). Systematic reviews of the literature show that various MMSE cut-offs have been used to define mild cognitive impairment, mild dementia and moderate dementia.[18 20] The MMSE was administered at re-survey in the Mexico City Prospective Study and we used cut-offs for mild dementia of ≤22 and ≤23 in the main analyses. The cut-off of ≤22 is recommended in the general population,[21] and it has been suggested that the cut-off of ≤23 be considered in older adults in Mexico.[22 23] Trained nurses implemented the re-survey questionnaire and assessed medical history. Cohort members who reported a diagnosis of dementia were excluded from the present analysis.

Confounders

Confounders that may influence the relationships between physical activity and cognition include age, sex, education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol.[3] Trained nurses implemented the baseline questionnaire. Participants were asked to report their age and sex. Participants were asked about education and we created five groups (none; at least some elementary; at least some high-school; at least some college; and at least some university). Participants reported their income and we created three groups (tertiles 1, 2 and 3). The nurses asked about smoking and we created three categories (never, former and current). Participants reported their civil status and we created three groups (not married or with partner; married or with partner; widowed). Participants were asked about sleep duration and we defined the at-risk group as sleeping <5 hours or >10 hours per night. Diet quality was expressed as fruit and vegetable intake (never; 1 or 2 days per week; 3 or 4 days per week; ≥5 days per week). The nurses also asked about alcohol drinking frequency and we created four categories (never; occasionally; at least once per week; and daily). At the end of the questionnaire, seated blood pressure was measured using a standard mercury sphygmomanometer and was expressed as the average of three measurements taken at 3 min intervals. Finally, weight and height were measured in light clothing and without shoes and body mass index was expressed as weight in kilograms divided by height in metres squared.

Statistical analyses

Participants' characteristics at baseline were described according to physical activity patterns. In the main analysis we investigated associations of physical activity patterns at baseline with mild dementia at re-survey. Cox models were created and hazard ratios and 95% CIs were calculated. Models were adjusted for age, sex, education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol at baseline. The proportional hazards assumption was checked graphically for discreet physical activity patterns and no violations were observed. In the secondary analysis we investigated the burden of mild dementia associated with low leisure time physical activity. The attributable fraction for low leisure time physical activity was defined as the proportion of cases of mild dementia that would not exist if all middle-aged adults were to take part in sport or exercise once or twice per week or more often. Attributable fractions were estimated using the methods described by Newson[24] and were adjusted for age, sex,

Table 1 Characteristics of participants at baseline according to physical activity patterns

	No sport or exercise	Weekend warrior pattern	Regularly active pattern
Number (%)	7945 (79.19)	726 (7.24)	1362 (13.58)
Age, years, mean (SD)	51.1 (10.7)	49.5 (10.5)	52.2 (10.8)
Sex			
Men, n (%)	2115 (26.62)	397 (54.68)	496 (36.42)
Women, n (%)	5830 (73.38)	329 (45.32)	866 (63.58)
Education			
None, n (%)	1029 (12.95)	45 (6.20)	84 (6.17)
Some elementary, n (%)	4408 (55.50)	313 (43.11)	631 (46.33)
Some high-school, n (%)	1748 (22.01)	214 (29.48)	384 (28.19)
Some college, n (%)	382 (4.81)	66 (9.09)	110 (8.08)
Some university, n (%)	376 (4.73)	88 (12.12)	153 (11.23)
Income			
Tertile 1 (lowest), n (%)	4026 (50.67)	228 (31.40)	630 (46.26)
Tertile 2, n (%)	1886 (23.74)	146 (20.11)	274 (20.12)
Tertile 3 (highest), n (%)	2033 (25.59)	352 (48.48)	458 (33.63)
Systolic pressure, mm Hg, mean (SD)	128 (16)	127 (15)	127 (15)
Smoking			
Never, n (%)	4367 (55.01)	296 (40.77)	662 (48.68)
Former, n (%)	1271 (16.01)	162 (22.31)	295 (21.69)
Current, n (%)	2301 (28.98)	268 (36.91)	403 (29.63)
Body mass index, kg/m^2, mean (SD)	29.6 (5.0)	28.4 (4.5)	28.7 (4.9)
Civil status			
Not married or with partner, n (%)	1153 (14.51)	108 (14.88)	200 (14.70)
Married or with partner, n (%)	5987 (75.36)	547 (75.34)	1042 (76.56)
Widowed, n (%)	805 (10.13)	71 (9.78)	119 (8.74)
Sleep duration <5 or >10 hours			
No, n (%)	7696 (96.87)	704 (96.97)	1325 (97.28)
Yes, n (%)	249 (3.13)	22 (3.03)	37 (2.72)
Fruit and vegetable intake			
Never, n (%)	76 (0.96)	1 (0.14)	8 (0.59)
1 or 2 days per week, n (%)	1361 (17.13)	101 (13.91)	112 (8.22)
3 or 4 days per week, n (%)	2286 (28.78)	223 (30.72)	289 (21.22)
≥5 days per week, n (%)	4221 (53.13)	401 (55.23)	953 (69.97)
Alcohol drinking			
Never, n (%)	1632 (20.54)	98 (13.50)	208 (15.27)
Occasionally, n (%)	5889 (74.12)	558 (76.86)	1073 (78.78)
At least once per week, n (%)	342 (4.30)	63 (8.68)	67 (4.92)
Daily, n (%)	82 (1.03)	7 (0.96)	14 (1.03)

education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol at baseline. We also investigated associations between physical activity and mild dementia stratified by sex. Finally, we investigated associations between physical activity and cognition stratified by the alternative MMSE scores of 21–24 for mild dementia and 13–20 for moderate dementia.[20] Cohort members who had a history of dementia at re-survey were removed from all analyses to minimise the possibility of reverse causation. All analyses were performed using Stata MP version 15.1 for Mac (StataCorp, Texas, USA).

Patient and public involvement

Patients and other members of the public were not involved in the design or conduct of this study.

Equity, diversity and inclusion

In the Mexico City Prospective Study, door-to-door interviews were conducted in the neighbouring districts of Coyoacán and Iztapalapa, at least one person was recruited from 94% of eligible households, and the final sample was broadly representative of the population aged ≥35 years in Mexico City. The author team includes three men and four women. Six of the authors live and work in Latin America and one author spends their time in both Europe and Latin America. Physical activity levels are reported according to age, sex, education, and income and associations between physical activity and health are adjusted for these important confounders. In the Discussion section we explain why the magnitude of the association between leisure time physical activity and cognitive decline may be different in Latin America and in high-income countries in Europe and North America.

RESULTS

Online supplemental figure S1 shows the flow of participants through the Mexico City Prospective Study. Data from 10 033 of 10 143 (99%) participants in the re-survey were included in the present analysis, after excluding 31 who did not complete

Table 2 Mini Mental State Examination scores at re-survey according to physical activity patterns at baseline

	Physical activity pattern		
	No sport or exercise	Weekend warrior	Regularly active
Number (%)	7945 (79.19)	726 (7.24)	1362 (13.58)
MMSE score, mean (SD)	24.54 (5.71)	25.85 (4.88)	25.56 (5.34)
MMSE score of ≤22			
No, n (%)	5900 (74.26)	623 (85.81)	1110 (81.50)
Yes, n (%)	2045 (25.74)	103 (14.19)	252 (18.50)
MMSE score of ≤23			
No, n (%)	5533 (69.64)	583 (80.30)	1061 (77.90)
Yes, n (%)	2412 (30.36)	143 (19.70)	301 (22.10)

The baseline surveys took place from 1998 to 2004 and the re-surveys from 2015 to 2019.
MMSE, Mini Mental State Examination.

the MMSE, 77 who had a history of dementia at re-survey, and two who had missing values for physical activity. Table 1 shows the participants' characteristics at baseline according to physical activity patterns. The average age was 51 years in those who reported no sport or exercise and was similar in the weekend warriors and the regularly active. The proportion of women was 73% in those who reported no sport or exercise and was lower in the other groups. The proportion with no education was 13% in those who reported no sport or exercise and was only 6% in the weekend warriors and the regularly active. The proportion in the lowest income tertile was 51% in those who reported no sport or exercise, 31% in the weekend warriors and 46% in the regularly active. The proportion who currently smoked was highest in the weekend warriors. Three-quarters of participants were married or with a partner. Three per cent of participants reported sleeping <5 hours or >10 hours per night. The frequency of fruit and vegetable intake tended to be higher in the weekend warriors and higher still in the regularly active. The proportion who drank alcohol at least once a week was highest in the weekend warriors. Systolic blood pressure and body mass index were similar in those who did and did not take part in sport or exercise.

Table 2 shows MMSE scores at re-survey according to physical activity patterns at baseline. The average MMSE score at re-survey was 24.5 in those who reported no sport or exercise at baseline, 25.8 in weekend warriors and 25.6 in the regularly active. The prevalence of mild dementia at re-survey was 26% in those who reported no sport or exercise at baseline, 14% in weekend warriors and 18.5% in the regularly active when defined as an MMSE score of ≤22. The prevalence of mild dementia was 30% in those who reported no sport or exercise at baseline, 20% in weekend warriors and 22% in the regularly active when defined as an MMSE score of ≤23.

Table 3 shows associations of physical activity patterns at baseline with cognition at re-survey, where mild dementia was defined as a score of ≤22 on the MMSE. Participants were followed for a mean (SD) of 16.2 (2.1) years and there were 2400 cases of mild dementia during 162 538 person-years of follow-up. Compared with the group that reported no sport or exercise, the hazard ratio for mild dementia was 0.75 (95% CI 0.61 to 0.91) in the weekend warrior group, 0.89 (95% CI 0.78 to 1.02) in the regularly active group and 0.84 (95% CI 0.75 to 0.95) in the combined group of weekend warriors and the regularly active after adjustment for age, sex, education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol at baseline.

Table 4 shows associations of physical activity patterns at baseline with cognition at re-survey, where mild dementia was defined as a score of ≤23 on the MMSE. There were 2856 cases of mild dementia. Compared with the group that reported no sport or exercise, the hazard ratio for mild dementia was 0.87 (95% CI 0.74 to 1.03) in the weekend warrior group, 0.88 (95% CI 0.78 to 1.00) in the regularly active group and 0.88 (95% CI 0.79 to 0.98) in the combined group of weekend warriors and the regularly active after adjustment for confounders.

The population attributable fraction for low leisure time physical activity was estimated while adjusting for age, sex, education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol at baseline. If mild dementia is defined as a score of ≤22 on the MMSE, theoretically 13% (95% CI 5% to 21%) of cases would be eliminated if all middle-aged adults were to take part in sport or exercise once or twice per week or more often. If mild dementia is defined as a score of ≤23, theoretically 10% (95% CI 2% to 18%) of cases would be eliminated if all middle-aged adults were to take part in sport or exercise once or twice per week or more often.

Table 5 shows associations of physical activity patterns at baseline with cognition at re-survey stratified by sex. The hazard ratios were similar in men and women. For example, when mild dementia was defined as a score of ≤22 on the MMSE, the hazard ratio was 0.73 (95% CI 0.51 to 1.03) in men who were weekend warriors and 0.75 (95% CI 0.59 to 0.96) in women who were weekend warriors after adjustment for confounders. Similarly, when mild dementia was defined as a score of ≤23, the hazard ratio was 0.88 (95% CI 0.66 to 1.17) in men who were weekend warriors and 0.87 (95% CI 0.70 to 1.07) in women who were weekend warriors. The confidence intervals were wider in the stratified analyses because the sample sizes were smaller than in the main analyses.

Table 3 Associations of physical activity patterns at baseline with mild dementia at re-survey using a score of ≤22 on the Mini Mental State Examination

Physical activity pattern	N/cases (% cases)	Adjusted for age and sex	Fully adjusted
No sport or exercise	7945/2045 (26%)	1.00 (Reference)	1.00 (Reference)
Weekend warrior	726/103 (14%)	0.63 (0.51 to 0.76)	0.75 (0.61 to 0.92)
Regularly active	1362/252 (18.5%)	0.72 (0.63 to 0.83)	0.89 (0.78 to 1.02)
Weekend warrior or regularly active	2088/355 (17%)	0.69 (0.62 to 0.78)	0.85 (0.75 to 0.95)

Values are hazard ratio (95% CI).
The baseline surveys took place from 1998 to 2004 and the re-surveys from 2015 to 2019. The duration of follow-up was mean (SD) 16.2 (2.1) years.
The fully-adjusted model was adjusted for age, sex, education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol at baseline.

Table 4 Associations of physical activity patterns at baseline with mild dementia at re-survey using a score of ≤23 on the Mini Mental State Examination

Physical activity pattern	N/cases (% cases)	Adjusted for age and sex	Fully adjusted
No sport or exercise	7945/2412 (30%)	1.00 (Reference)	1.00 (Reference)
Weekend warrior	726/143 (20%)	0.73 (0.62 to 0.87)	0.87 (0.74 to 1.03)
Regularly active	1362/301 (22%)	0.74 (0.65 to 0.83)	0.88 (0.78 to 1.00)
Weekend warrior or regularly active	2088/444 (21%)	0.74 (0.66 to 0.81)	0.88 (0.79 to 0.98)

Values are hazard ratio (95% CI).
The baseline surveys took place from 1998 to 2004 and the resurveys from 2015 to 2019. The duration of follow-up was mean (SD) 16.2 (2.1) years.
The fully-adjusted model was adjusted for age, sex, education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol at baseline.

Table 6 shows associations of physical activity patterns at baseline with cognition at re-survey stratified by the alternative MMSE scores of 21–24 for mild dementia and 13–20 for moderate dementia. There was little evidence that physical activity was associated with mild dementia when a range of MMSE scores was used to define the condition, but there was some evidence that physical activity was associated with moderate dementia when a range of scores was used to define the condition. For example, compared with the group that reported no sport or exercise, the hazard ratio for moderate dementia was 0.69 (95% CI 0.53 to 0.92) in the weekend warrior group and 0.83 (95% CI 0.71 to 0.98) in the combined group of weekend warriors and the regularly active after adjustment for confounders.

DISCUSSION

The main objective of this study was to investigate associations of the weekend warrior physical activity pattern with mild dementia in adults in Mexico City. We found that the weekend warrior physical activity pattern and the regularly active physical activity pattern were associated with similar reductions in mild dementia risks after adjustment for confounders. The secondary objective was to investigate the burden of mild dementia attributable to low leisure time physical activity. We found that around 10% of cases would be eliminated if all middle-aged adults were to take part in sport or exercise once or twice per week or more often. To the best of our knowledge, this is the first prospective cohort study to show that the weekend warrior physical activity pattern is associated with reduced risk of mild dementia.

Novelty and importance

Prospective cohort studies in Africa, East Asia and Pacific, Europe and North America suggest that leisure time physical activity is a major modifiable risk factor for cognitive decline and dementia.[4] Overall, compared with the inactive, the odds ratio for cognitive decline was 0.67 (95% CI 0.55 to 0.78) and the odds ratio for dementia was 0.79 (95% CI 0.69 to 0.88) in the physically active.[4] Consistency of association is a fundamental consideration in epidemiology[25]; however, to the best of our knowledge, this is the first prospective cohort study in Latin America to suggest that leisure time physical activity is associated with reduced risk of mild dementia. If it is assumed that odds ratios and hazard ratios are similar measures when risks are closer to 1.0 than 2.5,[26] then it is noteworthy that the reduction in risk of cognitive decline was greater in other studies than in the present study.[4] These differences in risk may be explained by the high amounts of non-exercise physical activity that are part of everyday life in many cities in Latin America.[27–29] For example, if the non-exercise group were to take part in large amounts of walking for transport in Latin America, then the difference in risk between the exercise and non-exercise groups would not be as great as in other regions. It is encouraging that the weekend warrior group, the regularly active group and the combined group were associated with reduced risks in the present study because physical activity patterns may change over time.[14] For example, we found that, among cohort members who reported being weekend warriors at baseline, 21% reported being regularly active at re-survey.[14] Similarly, among cohort

Table 5 Associations of physical activity patterns at baseline with mild dementia at re-survey stratified by sex

	Men		Women	
Physical activity pattern	N/cases (% cases)	HR	N/cases (% cases)	HR
MMSE score of ≤22				
No sport or exercise	2093/507 (24%)	1.00 (Reference)	5798/1520 (26 %)	1.00 (Reference)
Weekend warrior	394/35 (9%)	0.73 (0.51 to 1.03)	329/68 (21%)	0.75 (0.59 to 0.96)
Regularly active	494/86 (17%)	0.82 (0.65 to 1.04)	862/164 (19%)	0.91 (0.78 to 1.01)
Weekend warrior or regularly active	888/121 (14%)	0.79 (0.65 to 0.97)	1191/232 (19.5%)	0.86 (0.75 to 0.99)
MMSE score of ≤23				
No sport or exercise	2093/606 (29%)	1.00 (Reference)	5798/1784 (31%)	1.00 (Reference)
Weekend warrior	394/53 (13%)	0.88 (0.66 to 1.17)	329/90 (27%)	0.87 (0.70 to 1.07)
Regularly active	494/102 (21%)	0.81 (0.65 to 1.00)	862/196 (23%)	0.91 (0.79 to 1.06)
Weekend warrior or regularly active	888/155 (17%)	0.83 (0.69 to 1.00)	1191/286 (24%)	0.90 (0.79 to 1.02)

Values are hazard ratio (95% CI).
The models were adjusted for age, education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol at baseline.
MMSE, Mini Mental State Examination.

Table 6 Associations of physical activity patterns at baseline with cognition at re-survey stratified by the alternative MMSE scores for mild and moderate dementia

Physical activity pattern	N/cases (% cases)	HR
MMSE score of 21–24 for mild dementia		
No sport or exercise	6427/1339 (21%)	1.00 (Reference)
Weekend warrior	653/111 (17%)	1.13 (0.93, to1.38)
Regularly active	1187/189 (16%)	0.93 (0.80 to 1.09)
Weekend warrior or regularly active	1840/300 (16%)	1.00 (0.88 to 1.14)
MMSE score of 13–20 for moderate dementia		
No sport or exercise	6250/1162 (19%)	1.00 (Reference)
Weekend warrior	595/53 (9%)	0.69 (0.53 to 0.92)
Regularly active	1128/130 (11.5%)	0.91 (0.75 to 1.09)
Weekend warrior or regularly active	1723/183 (11%)	0.83 (0.71 to 0.98)

Values are hazard ratio (95% CI).
The models were adjusted for age, sex, education, income, systolic blood pressure, smoking, body mass index, civil status, sleep duration, fruit and vegetable intake and alcohol at baseline.
MMSE, Mini Mental State Examination.

members who reported being regularly active at baseline, 6% reported being weekend warriors at re-survey.[14] It is plausible that physical activity improves brain health and several potential mechanisms have been identified.[30–35] For example, exercise may increase brain-derived neurotrophic factor concentrations and brain plasticity.[30] Physical activity is also associated with greater brain volume, greater executive function and greater memory.[31]

Policy implications

Cross-sectional studies in Europe[36] and North America[37] suggest that the weekend warrior physical activity pattern is associated with mental health benefits. For example, Hamer and colleagues found that, compared with the inactive, the odds ratio for psychological distress was 0.68 (95% CI 0.63 to 0.73) in weekend warriors and 0.68 (95% CI 0.64 to 0.72) in the regularly active in the UK.[36] To the best of our knowledge, the present study is the first prospective cohort study to show that the weekend warrior physical activity pattern and the regularly active physical activity pattern are associated with similar reductions in the risk of mild dementia. The present study has important implications for policy and practice because the weekend warrior physical activity pattern may be a more convenient option for busy people in Latin America[6–8] and elsewhere.[5 38] It is particularly encouraging that the weekend warrior physical activity pattern was associated with reduced risk of mild dementia in both men and women in the present study because lack of time is a major barrier to leisure time physical activity in men and women around the world.[6–8] In Latin America, as many as eight out of 10 adults say they would like to do more sport,[8] and it is reasonable to suggest that more men and women in the region would exercise if they knew that taking part in one or two sessions per week was associated with considerable cognitive health benefits. Hundreds of cities in Latin America provide a free-of-charge physical activity intervention every weekend that is known as the Ciclovía Recreativa.[39–41] In Mexico City, for example, more than 50 km of roads are closed to motor vehicles on Sundays and the streets fill with around 80 000 walkers, runners and cyclists.[42 43] Sunday is the ideal day for the Ciclovía Recreativa because many people in Mexico and elsewhere in Latin America work long hours from Monday to Saturday.[44] Indeed, most participants say they would not exercise if it were not for the Ciclovía Recreativa.[42 45] In Mexico alone, the cost of dementia is around US$ 3776 million per year.[46] If it is assumed that mild dementia leads to dementia and that the attributable fraction for low leisure time physical activity is around 10%, as suggested in the present study, then around US$ 377.6 million per year would be saved if all middle-aged adults were to take part in sport or exercise once or twice per week or more often. The human and economic costs of mild dementia and dementia suggest that more could be done to promote the Ciclovía Recreativa and other successful physical activity interventions in Mexico.

Strengths and limitations

This study has strengths and limitations. All analyses were adjusted for major confounders[3] and cohort members with a history of dementia at re-survey were removed to minimise the possibility of reverse causation. The relatively long follow-up period also makes reverse causation unlikely.[3] Creating large samples and obtaining high response rates are among the main goals of data collection in cohort studies.[47] The Mexico City Prospective Study is deemed to be broadly representative of the population aged ≥35 years by virtue of the large sample size of more than 150 000 adults and the high response rate of at least one participant from more than 94% of eligible households.[10] However, it is not clear whether the original survey or the re-survey are representative because recruitment was not stratified according to demographic parameters such as age, gender or socioeconomic status. Physical activity, dementia history and other variables were self-reported, which may introduce bias. Questionnaires were used to assess physical activity, but it is preferable to use both questionnaires and accelerometers to assess physical activity in cohort studies because each method has advantages and disadvantages.[48–50] For example, questionnaires might best be used to identify types of sport and exercise and accelerometers might best be used to assess volumes of physical activity. English and Spanish versions of the MMSE are valid screening tools,[23 51] but they are not clinical diagnoses of cognitive impairment or dementia. The sample size in the combined group of weekend warriors and the regularly active in the main analyses was large enough to give precise estimates of the associations between physical activity and mild dementia, as indicated by the relatively narrow confidence intervals. However, larger samples of weekend warriors and larger samples of the regularly active may be required to give more precise estimates of risk in future studies. Larger sub-samples of men and women may also be required to give more precise estimates of risk. There was little evidence that physical activity was associated with mild dementia and some evidence that physical activity was associated with moderate dementia when ranges of MMSE scores were used to define the conditions. However, these data should be treated with some caution because there is a greater risk of misclassification when several categories are used rather than a single cut-off (using the three categories of referent, mild and moderate, there are four possible misclassifications of one category higher or lower than the correct category and six possible misclassifications of one or two categories higher or lower than the correct category).[52] Future studies should also include continuous measures of cognition because statistical power is increased when continuous variables are used rather than categorical variables.

CONCLUSIONS

To the best of our knowledge, this is the first prospective cohort study to show that the weekend warrior physical activity pattern

and the regularly active physical activity pattern are associated with similar reductions in the risk of mild dementia. This study has important implications for policy and practice because the weekend warrior physical activity pattern may be a more convenient option for busy people around the world.

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REFERENCES

1 GBD 2019 Dementia Forecasting Collaborators. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. *Lancet Public Health* 2022;7:e105–25.
2 Jorm AF, Korten AE, Henderson AS. The prevalence of dementia: a quantitative integration of the literature. *Acta Psychiatr Scand* 1987;76:465–79.
3 Livingston G, Huntley J, Sommerlad A, *et al*. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *Lancet* 2020;396:413–46.
4 Guure CB, Ibrahim NA, Adam MB, *et al*. Impact of Physical Activity on Cognitive Decline, Dementia, and Its Subtypes: Meta-Analysis of Prospective Studies. *Biomed Res Int* 2017;2017:9016924.
5 O'Donovan G, Sarmiento OL, Hamer M. The Rise of the "Weekend Warrior." *J Orthop Sports Phys Ther* 2018;48:604–6.
6 Reichert FF, Barros AJD, Domingues MR, *et al*. The role of perceived personal barriers to engagement in leisure-time physical activity. *Am J Public Health* 2007;97:515–9.
7 Herazo-Beltrán Y, Pinillos Y, Vidarte J, *et al*. Predictors of perceived barriers to physical activity in the general adult population: a cross-sectional study. *Braz J Phys Ther* 2017;21:44–50.
8 IPSOS. Puntos de vista globales sobre los deportes: al 58% a nivel mundial le gustaría practicar más [Global perspectives on sport: 58% of people would like to do more]. 2021. Available: https://www.ipsos.com/es-mx/puntos-de-vista-globales-sobre-los-deportes-al-58-nivel-mundial-le-gustaria-practicar-mas [Accessed Nov 2023].
9 Katzmarzyk PT, Friedenreich C, Shiroma EJ, *et al*. Physical inactivity and non-communicable disease burden in low-income, middle-income and high-income countries. *Br J Sports Med* 2022;56:101–6.
10 Tapia-Conyer R, Kuri-Morales P, Alegre-Díaz J, *et al*. Cohort profile: the Mexico City Prospective Study. *Int J Epidemiol* 2006;35:243–9.
11 Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep* 1985;100:126–31.
12 Bouchard C, Shephard RJ. Physical activity, fitness and health: the model and key concepts. In: Bouchard C, Shephard RJ, Stephens T, eds. *Physical Activity, Fitness and Health: International Proceedings and Consensus Statement*. Champaign, IL: Human Kinetics, 1994.
13 Council of Europe. *European sports charter. Recommendation no. R(92) 13*. London: Sports Council, 1993. Available: https://ec.europa.eu/assets/eac/sport/library/documents/doc252_en.pdf
14 O'Donovan G, Petermann-Rocha F, Ferrari G, *et al*. Associations of the "weekend warrior" physical activity pattern with all-cause, cardiovascular disease and cancer mortality: the Mexico City Prospective Study. *Br J Sports Med* 2024;58:359–65.
15 Milton K, Bull FC, Bauman A. Reliability and validity testing of a single-item physical activity measure. *Br J Sports Med* 2011;45:203–8.
16 Jackson AW, Morrow JR, Bowles HR, *et al*. Construct validity evidence for single-response items to estimate physical activity levels in large sample studies. *Res Q Exerc Sport* 2007;78:24–31.
17 Taylor P, Davies L, Wells P, *et al*. A review of the social impacts of culture and sport [Department for Culture, Media and Sport]. 2015. Available: https://assets.publishing.service.gov.uk/media/5a74a738ed915d0e8bf1a0d6/A_review_of_the_Social_Impacts_of_Culture_and_Sport.pdf [Accessed Nov 2023].
18 Patnode CD, Perdue LA, Rossom RC, *et al*. Screening for Cognitive Impairment in Older Adults: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. *JAMA* 2020;323:764–85.
19 Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189–98.
20 Lin JS, O'Connor E, Rossom RC, *et al*. Screening for cognitive impairment in older adults: an evidence update for the U.S. Preventive Services Task Force. Rockville (MD): Agency for Healthcare Research and Quality (US); 2013. Available: https://pubmed.ncbi.nlm.nih.gov/24354019/
21 Psychological Assessment Resources Inc. Mini-mental state examination. Available: https://www.parinc.com/Products/Pkey/237 [Accessed Dec 2023].
22 García-Peña C, Wagner FA, Sánchez-Garcia S, *et al*. Depressive symptoms among older adults in Mexico City. *J Gen Intern Med* 2008;23:1973–80.

23 Beaman SR de, Beaman PE, Garcia-Peña C, *et al*. Validation of a Modified Version of the Mini-Mental State Examination (MMSE) in Spanish. *Aging Neuropsychol Cogn* 2004;11:1–11.
24 Newson RB. Attributable and Unattributable Risks and Fractions and other Scenario Comparisons. *Stata J* 2013;13:672–98.
25 VanderWeele TJ, Lash TL, Rothman KJ. Causal inference and scientific reasoning. In: Lash TL, VanderWeele TJ, Haneuse S, *et al*., eds. *Modern Epidemiology*. 4th edn. Philadelphia: Wolters Kluwer, 2021.
26 Symons MJ, Moore DT. Hazard rate ratio and prospective epidemiological studies. *J Clin Epidemiol* 2002;55:893–9.
27 Salvo D, Jáuregui A, Adlakha D, *et al*. When Moving Is the Only Option: The Role of Necessity Versus Choice for Understanding and Promoting Physical Activity in Low- and Middle-Income Countries. *Annu Rev Public Health* 2023;44:151–69.
28 Inter-American Development Bank. The role of active transport modes in enhancing the mobility of low-income people in Latin America and the Caribbean. Available: https://publications.iadb.org/en/role-active-transport-modes-enhancing-mobility-low-income-people-latin-america-and-caribbean [Accessed Jun 2023].
29 Delclòs-Alió X, Rodríguez DA, Medina C, *et al*. Walking for transportation in large Latin American cities: walking-only trips and total walking events and their sociodemographic correlates. *Transp Rev* 2022;42:296–317.
30 Ribeiro D, Petrigna L, Pereira FC, *et al*. The Impact of Physical Exercise on the Circulating Levels of BDNF and NT 4/5: A Review. *Int J Mol Sci* 2021;22:8814.
31 Domingos C, Pêgo JM, Santos NC. Effects of physical activity on brain function and structure in older adults: A systematic review. *Behav Brain Res* 2021;402:113061.
32 Moore D, Jung M, Hillman CH, *et al*. Interrelationships between exercise, functional connectivity, and cognition among healthy adults: A systematic review. *Psychophysiology* 2022;59:e14014.
33 Barnes JN, Pearson AG, Corkery AT, *et al*. Exercise, Arterial Stiffness, and Cerebral Vascular Function: Potential Impact on Brain Health. *J Int Neuropsychol Soc* 2021;27:761–75.
34 Won J, Callow DD, Pena GS, *et al*. Evidence for exercise-related plasticity in functional and structural neural network connectivity. *Neurosci Biobehav Rev* 2021;131:923–40.
35 Cheatham CL, Nieman DC, Neilson AP, *et al*. Enhancing the Cognitive Effects of Flavonoids With Physical Activity: Is There a Case for the Gut Microbiome? *Front Neurosci* 2022;16:833202.
36 Hamer M, Biddle SJH, Stamatakis E. Weekend warrior physical activity pattern and common mental disorder: a population wide study of 108,011 British adults. *Int J Behav Nutr Phys Act* 2017;14:96.
37 Liang J-H, Huang S, Pu Y-Q, *et al*. Whether weekend warrior activity and other leisure-time physical activity pattern reduce the risk of depression symptom in the representative adults? A population-based analysis of NHANES 2007-2020. *J Affect Disord* 2023;340:329–39.
38 Trost SG, Owen N, Bauman AE, *et al*. Correlates of adults' participation in physical activity: review and update. *Med Sci Sports Exerc* 2002;34:1996–2001.
39 Sarmiento OL, Díaz Del Castillo A, Triana CA, *et al*. Reclaiming the streets for people: Insights from Ciclovías Recreativas in Latin America. *Prev Med* 2017;103S:S34–40.
40 Ciclovías Recreativas de las Américas. La Ciclovía Recreativa, el evento recreativo y de recuperación de espacios públicos más grande del mundo [Open Streets: the world's largest initiative to facilitate physical activity and to recover public space]. Available: https://cicloviasrecreativas.org [Accessed Jun 2023].
41 Mejia-Arbelaez C, Sarmiento OL, Mora Vega R, *et al*. Social Inclusion and Physical Activity in Ciclovía Recreativa Programs in Latin America. *Int J Environ Res Public Health* 2021;18:655.
42 Medina C, Romero-Martinez M, Bautista-Arredondo S, *et al*. Move on Bikes Program: A Community-Based Physical Activity Strategy in Mexico City. *Int J Environ Res Public Health* 2019;16:1685.
43 Secretaría de Movilidad. Muévete en Bici [On Your Bike]. Available: https://www.semovi.cdmx.gob.mx/tramites-y-servicios/mi-bici/muevete-en-bici [Accessed Jun 2023].
44 OECD. Hours worked (indicator). 2024. Available: https://data.oecd.org/emp/hours-worked.htm [Accessed Jan 2024].
45 Montes F, Sarmiento OL, Zarama R, *et al*. Do health benefits outweigh the costs of mass recreational programs? An economic analysis of four Ciclovía programs. *J Urban Health* 2012;89:153–70.
46 Mattap SM, Mohan D, McGrattan AM, *et al*. The economic burden of dementia in low- and middle-income countries (LMICs): a systematic review. *BMJ Glob Health* 2022;7:e007409.
47 Wise LA, Hartge P. Field methods. In: Lash TL, VanderWeele TJ, Haneuse S, *et al*., eds. *Modern Epidemiology*. 4th edn. Philadelphia: Wolters Kluwer, 2021.
48 Sattler MC, Ainsworth BE, Andersen LB, *et al*. Physical activity self-reports: past or future? *Br J Sports Med* 2021;55:889–90.
49 Nigg CR, Fuchs R, Gerber M, *et al*. Assessing physical activity through questionnaires – A consensus of best practices and future directions. *Psychol Sport Exerc* 2020;50:101715.
50 Burchartz A, Anedda B, Auerswald T, *et al*. Assessing physical behavior through accelerometry – State of the science, best practices and future directions. *Psychol Sport Exerc* 2020;49:101703.
51 Webster L, Groskreutz D, Grinbergs-Saull A, *et al*. Core outcome measures for interventions to prevent or slow the progress of dementia for people living with mild to moderate dementia: Systematic review and consensus recommendations. *PLoS One* 2017;12:e0179521.
52 Flegal KM, Kit BK, Graubard BI. Bias in Hazard Ratios Arising From Misclassification According to Self-Reported Weight and Height in Observational Studies of Body Mass Index and Mortality. *Am J Epidemiol* 2018;187:125–34.