





Associations of the 'weekend warrior' physical activity pattern with all-cause, cardiovascular disease and cancer mortality: the Mexico City Prospective Study

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► Additional supplemental material is published online only. To view, please visit the journal online (<https://doi.org/10.1136/bjsports-2023-107612>).

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Accepted 21 January 2024
Published Online First
1 February 2024

ABSTRACT

Objectives The objective was to investigate the benefits of the 'weekend warrior' physical activity pattern in Latin America, where many people take part in high levels of non-exercise physical activity.

Methods Participants in the Mexico City Prospective Study were surveyed from 1998 to 2004 and resurveyed from 2015 to 2019. Those who exercised up to once or twice per week were termed weekend warriors. Those who exercised more often were termed regularly active. Analyses were adjusted for potential confounders.

Results The main analysis included 26 006 deaths in 154 882 adults (67% female) aged 52±13 years followed for 18±4 years (mean±SD). Compared with those who reported no exercise, the HR (95% CI) was 0.88 (0.83 to 0.93) in the weekend warriors and 0.88 (0.84 to 0.91) in the regularly active. Similar results were observed for cardiovascular disease and cancer mortality, but associations were weaker. Stratified analyses showed that substantial reductions in all-cause mortality risk only occurred when the duration of exercise sessions was at least 30–60 min. The repeated-measures analysis included 843 deaths in 10 023 adults followed for 20±2 years. Compared with being inactive or becoming inactive, the HR was 0.86 (95% CI 0.65 to 1.12) when being a weekend warrior or becoming a weekend warrior and 0.85 (95% CI 0.70 to 1.03) when being regularly active or becoming regularly active.

Conclusions This is the first prospective study to investigate the benefits of the weekend warrior physical activity pattern in Latin America. The results suggest that even busy adults could benefit from taking part in one or two sessions of exercise per week.

INTRODUCTION

Physical activity is regarded as one of the leading modifiable risk factors for morbidity and mortality worldwide.^{1,2} The promotion of physical activity is also thought to be beneficial to meeting 15 of the 17 United Nations Sustainable Development Goals.³ Nonetheless, relatively little is known about the benefits of physical activity in low-income and middle-income countries in Latin America, where participation in large amounts of physical activity is a necessity, not a choice.^{3–8} Indeed, poverty, crime, informal work and the cost of car ownership make walking for transport inevitable.^{4–6} Roughly,

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The 'weekend warrior' takes part in one or two sessions of sport or exercise per week and studies in high-income countries in Europe and North America suggest that the benefits of exercising once or twice per week are similar to exercising more often.

WHAT THIS STUDY ADDS

- ⇒ To the best of our knowledge, the Mexico City Prospective Study is the largest cohort study in Mexico or elsewhere in Latin America.
- ⇒ The study is also one of the few cohort studies anywhere in the world to include repeated measures of physical activity and potential confounders.
- ⇒ In this analysis of more than 150 000 cohort members, all-cause mortality risk was reduced by approximately 15% in the 'weekend warriors' who exercised once or twice per week and in the 'regularly active' who exercised more often.
- ⇒ For both the weekend warrior pattern and the regularly active pattern, substantial reductions in risk only occurred when the duration of exercise sessions was at least 30–60 min.
- ⇒ In the repeated measures analysis, we found some evidence that being a weekend warrior or becoming a weekend warrior was associated with a reduced risk of mortality.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ The weekend warrior physical activity pattern may be a more convenient option for busy people.
- ⇒ There are high levels of non-exercise physical activity in many cities in Latin America and this study is important because it suggests that even busy people could benefit from taking part in one or two sessions of sport and exercise per week.

30%–45% of all journeys are made on foot in low-income groups in cities in Latin America, compared with around 20% of journeys in higher-income groups.⁴ Furthermore, around 20%–25%



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To cite: O'Donovan G, Petermann-Rocha F, Ferrari G, et al. *Br J Sports Med* 2024;**58**:359–365.

of residents in large cities in Latin America meet prevailing physical activity guidelines just by walking for transport.⁹ Participation in sport and exercise may be more beneficial to health than participation in occupational physical activity and other types of physical activity.^{10,11} Therefore, it is important to investigate the benefits of taking part in sport and exercise.

The ‘weekend warrior’ takes part in one or two sessions of sport or exercise per week and studies in high-income countries in Europe and North America suggest that the benefits of exercising once or twice per week are much the same as exercising more often.^{12–14} The weekend warrior physical activity pattern may be more convenient^{15,16} and it may be particularly important to investigate the benefits of different physical activity patterns in low-income and middle-income countries in Latin America because lack of time is a major barrier to physical activity in the region.^{15,17,18} It may be particularly advantageous to investigate the benefits of the weekend warrior physical activity pattern in Latin America because the region is home to a weekly physical activity intervention known as the *Ciclovia Recreativa*.¹⁹ The *Ciclovia Recreativa* is a remarkably simple intervention in which main roads are closed to motor vehicles and are opened exclusively for people to enjoy a safe, free space to exercise.¹⁹ Millions of people across Latin America take part in the *Ciclovia Recreativa* every weekend^{19–21} and most participants say they would not exercise if it were not for the *Ciclovia Recreativa*.^{22,23} The health and economic impacts of the *Ciclovia Recreativa* in 15 cities in Latin America have been conservatively estimated to include the prevention of around 360 premature deaths per year and the associated cost saving of around US\$200 million per year.²⁰

Consistency of association is one of the fundamental considerations when inferring causality²⁴ and it is important to gather evidence from settings other than high-income countries in Europe and North America. Mexico is an upper-middle-income country in Latin America²⁵ and the Mexico City Prospective Study is a large cohort study that includes measures of physical activity, mortality and potential confounders.²⁶ The main objective of the present analysis was to investigate associations of the weekend warrior physical activity pattern with all-cause, cardiovascular disease (CVD) and cancer mortality in the Mexico City Prospective Study. Participation in sport and exercise may change over the life course,²⁷ yet few cohort studies include repeated measures of physical activity.^{28–31} Participants in the Mexico City Prospective Study were assessed at baseline and after around 16 years and the secondary objective of the present analysis was to investigate associations of physical activity patterns with mortality using repeated measures of physical activity and potential confounders.

METHODS

Participants

The Mexico City Prospective Study is described in detail elsewhere.²⁶ 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.²⁶ Recruitment teams then visited households and at least one participant aged 35 years or older was recruited from 94% of eligible households.²⁶ The resulting sample was deemed to be broadly representative of the population aged 35 years or older in Mexico City.²⁶ Trained nurses collected data in the participant’s household and the baseline survey took place from 1998 to 2004 and the resurvey took place from 2015 to 2019.²⁶ The data used in the current report were obtained through an

open-access data request made to the Mexico City Prospective Study principal investigators.

Defining physical activity, exercise and sport

In the broadest sense, physical activity is defined as any volitional movement of skeletal muscle that results in energy expenditure.³² Exercise is a form of leisure-time physical activity that is planned, structured and repetitive. Exercise training is purposeful and is performed with specific external goals, including the improvement or maintenance of physical fitness, physical performance or health.^{32,33} Sport is a form of physical activity that includes rules and is usually competitive. The true sense of sport is broad: ‘Sport means all forms of physical activity, which, through casual or organised participation, aim at expressing or improving physical fitness and mental well-being, forming social relationships or obtaining results in competition at all levels’.³⁴ The terms ‘sport’ and ‘exercise’ can have negative connotations in Europe and North America,³⁵ but asking someone what sport they like in Latin America is as innocent a question as asking them what music they like.¹⁸

Exposure

The exposure was leisure-time physical activity. 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). And, they were asked how many minutes they spent exercising per session (less than 30; from 30 to 60; or more than 60). Similar questions were asked 16 years later at resurvey and we created three exposure groups. 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. Simple physical activity assessment tools like the one used in the present study have been validated against multiple-item physical activity assessment tools³⁶ and against cardiorespiratory fitness.³⁷

Outcomes

The registration of deaths in Mexico is thorough, with almost all deaths certified medically and with few deaths attributed to unknown causes.³⁸ The outcomes were all-cause mortality, CVD mortality and cancer mortality. Mortality was tracked to 31 December 2020 through probabilistic linkage to the national death register based on the participant’s name, age and sex. Diseases listed on the death certificates were coded according to the International Classification of Diseases, 10th Revision.³⁹

Potential confounders

Potential confounders that may influence the relationships between physical activity and mortality include age, sex, education, income, smoking, diet and alcohol.^{40–42} Body mass index, hypertension, diabetes and other such variables might be regarded as biological intermediates, not confounding factors.^{2,43} Trained nurses recorded age and sex. Participants were asked about education at baseline and resurvey 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 were asked about income at baseline and resurvey and we created three groups (tertile 1, tertile 2 and tertile 3). The trained nurses asked about smoking at baseline and resurvey

and we created three categories (never, former and current). Participants were also asked about alcohol drinking frequency and we created four categories (never, occasionally, at least once per week and daily). Finally, diet quality at baseline and resurvey was expressed as fruit and vegetable intake (never, 1 or 2 days per week, 3 or 4 days per week and 5 or more days per week).

Statistical analyses

Participants' characteristics at baseline were described according to physical activity patterns. Associations of physical activity patterns with mortality were investigated using Cox models. The proportional hazards assumption was checked graphically for the discrete physical activity patterns and no violations were observed. In the main analysis, we used a single-measure design. We investigated associations of physical activity patterns at baseline with mortality. We also investigated associations stratified by the length of time spent exercising at each session. The simple physical activity questionnaire allowed us to investigate three strata: less than 30 min per session; from 30 to 60 min per session and more than 60 min per session. Analyses were adjusted for age, sex, education, income, smoking, fruit and vegetable intake, and alcohol. In a sensitivity analysis, associations of physical activity patterns at baseline with all-cause mortality were further adjusted for self-reported illnesses at baseline, including diabetes, hypertension, heart attack, stroke and cancer.

In the secondary analyses, we used a repeated-measures design. We investigated associations of physical activity patterns with mortality using repeated measures of physical activity and potential confounders. The analysis included baseline measures of age and sex as well as baseline and resurvey measures of physical activity, education, income, smoking and alcohol. Physical activity, education, income, smoking, fruit and vegetable intake, and alcohol were treated as time-varying variables. The analysis included all the available data for each variable, whether the data were available at baseline, resurvey or both. Robust estimates of variance were used to obtain the confidence intervals in the repeated-measures analysis because conventional estimates of variance are not appropriate when observations are dependent. Participants who died during the first 2 years of follow-up were removed from all analyses to minimise the possibility of reverse causation. All analyses were performed by using Stata SE V.17.0 for Mac (StataCorp).

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 or older in Mexico City. The author team includes six men and three women. Five 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 mortality 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 study. Data from 154 882 of 159 517 (97%) cohort members were included in the main analysis, after excluding 2530 people who died during the first 2 years of follow-up and 2105 with missing values for the exposures or the outcomes. Table 1 shows participants' characteristics at baseline according to physical activity patterns. Age was around 52 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 70% in those who reported no sport or exercise and was lower in the other groups. The proportion with no education was 15% in those who reported no sport or exercise and was only 7% in the weekend warriors and the regularly active. The proportion in the lowest income tertile was approximately 50% in those who reported no sport or exercise, 31% in the weekend warriors and 43% in the regularly active. The proportion who had never smoked was around 50% in those who reported no sport or exercise and was lower in the other groups. The proportion who currently smoked was highest in the weekend warriors. The proportion who had never drunk alcohol was around 21% in those who reported no sport or exercise and was lower in the other groups. The proportion who drank at least once a week was highest in the weekend warriors. The frequency of fruit and vegetable intake tended to be higher in the weekend warriors and higher still in the regularly active.

Table 2 shows associations of physical activity patterns at baseline with mortality risks. Participants were followed for 17.6 ± 4.0 years (mean \pm SD) and there were a total of 26 006 deaths from all causes during 2 721 235 person-years of follow-up. Compared with the group that reported no sport or exercise, the HR (95% CI) was 0.88 (0.84 to 0.93) in the weekend warrior group and 0.88 (0.85 to 0.91) in the regularly active group after adjustment for age, sex, education, income, smoking, fruit and vegetable intake, and alcohol. There were a total of 8750 deaths from CVD. Compared with the group that reported no sport or exercise, the fully adjusted HR was 0.94 (95% CI 0.86 to 1.03) in the weekend warrior group and 0.93 (95% CI 0.87 to 0.99) in the regularly active group. Finally, there were a total of 3409 deaths from cancer. Compared with the group that reported no sport or exercise, the fully adjusted HR was 0.82 (95% CI 0.71 to 0.95) in the weekend warrior group and 0.94 (95% CI 0.86 to 1.04) in the regularly active groups. Online supplemental table S1 shows the results of the sensitivity analysis. Associations of physical activity patterns with all-cause mortality were similar after further adjustment for diabetes, hypertension, heart attack, stroke and cancer.

Table 3 shows associations of physical activity patterns at baseline with all-cause mortality risk stratified by the length of time spent exercising at each session. The first stratum was less than 30 min per session. Compared with the group that reported no sport or exercise, the HR (95% CI) was 1.03 (0.94 to 1.14) in the weekend warrior group and 0.95 (0.89 to 1.01) in the regularly active group after adjustment for age, sex, education, income, smoking, fruit and vegetable intake, and alcohol. The second stratum was 30–60 min per session. Compared with the group that reported no sport or exercise, the fully adjusted HR was 0.84 (95% CI 0.78 to 0.91) in the weekend warrior group and 0.88 (95% CI 0.84 to 0.93) in the regularly active group. The third stratum was more than 60 min per session. Compared with the group that reported no sport or exercise, the fully adjusted HR was 0.80 (95% CI 0.75 to 0.89) in the weekend warrior group and 0.81 (95% CI 0.75 to 0.86) in the regularly active group.

Table 1 Participants' characteristics at baseline according to physical activity patterns

	Physical activity pattern		
	No sport or exercise	Weekend warrior	Regularly active
No (%)	120 325 (77.69)	11 981 (7.74)	22 576 (14.58)
Age, years, mean±SD	52.3±13.1	49.9±12.1	53.3±12.8
Sex			
Male, n (%)	35 579 (29.57)	6 595 (55.05)	8 563 (37.93)
Female, n (%)	84 746 (70.43)	5 386 (44.95)	14 013 (62.07)
Education			
None, n (%)	17 899 (14.88)	820 (6.85)	1 473 (6.53)
At least some elementary, n (%)	59 384 (49.37)	4 451 (37.16)	8 714 (38.61)
At least some high-school, n (%)	27 816 (23.13)	3 627 (30.28)	6 509 (28.84)
At least some college, n (%)	6 731 (5.60)	1 240 (10.35)	2 111 (9.35)
At least some university, n (%)	8 442 (7.02)	1 840 (15.36)	3 764 (16.68)
Income			
Tertile 1 (lowest), n (%)	59 480 (49.43)	3 729 (31.12)	9 746 (43.17)
Tertile 2, n (%)	25 204 (20.95)	2 102 (17.54)	4 115 (18.23)
Tertile 3 (highest), n (%)	35 641 (29.62)	6 150 (51.33)	8 715 (38.60)
Smoking			
Never, n (%)	61 036 (50.76)	4 684 (39.13)	10 055 (44.57)
Former, n (%)	22 356 (18.59)	2 647 (22.11)	5 615 (24.89)
Current, n (%)	36 843 (30.64)	4 640 (38.76)	6 892 (30.55)
Alcohol			
Never, n (%)	25 780 (21.43)	1 566 (13.08)	3 511 (15.56)
Occasionally, n (%)	87 836 (73.02)	9 052 (75.58)	17 314 (76.72)
At least once per week, n (%)	5 353 (4.45)	1 217 (10.16)	1 473 (6.53)
Daily, n (%)	1 325 (1.10)	142 (1.19)	269 (1.19)
Fruit and vegetable intake			
Never, n (%)	1 430 (1.19)	103 (0.86)	119 (0.53)
1 or 2 days per week, n (%)	22 394 (18.62)	1 842 (15.38)	1 928 (8.54)
3 or 4 days per week, n (%)	35 276 (29.32)	3 275 (27.34)	4 610 (20.42)
5 or more days per week, n (%)	61 198 (50.87)	6 758 (56.42)	15 917 (70.51)

Table 4 shows physical activity patterns at baseline and resurvey. The present study included 10 023 of 10 143 (99%) cohort members who were resurveyed after 19.7±1.9 years. Among those who reported no sport or exercise at baseline, 6688 (84%) reported being inactive at resurvey, 318 (4%) reported being weekend warriors at resurvey, and 930 (12%) reported being regularly active at resurvey. Among those who reported

being weekend warriors at baseline, 474 (65%) reported being inactive at resurvey, 100 (14%) reported being weekend warriors at resurvey and 152 (21%) reported being regularly active at resurvey. Among those who reported being regularly active at baseline, 847 (62%) reported being inactive at resurvey, 85 (6%) reported being weekend warriors at resurvey and 432 (32%) reported being regularly active at resurvey.

Table 2 Associations of physical activity patterns at baseline with mortality risks*

Physical activity pattern	N	Deaths	Adjusted for age and sex	Fully adjusted
All-cause mortality				
No sport or exercise	120 325	20 791	1.00 (Reference)	1.00 (Reference)
Weekend warrior	11 981	1 583	0.84 (0.80 to 0.88)	0.88 (0.84 to 0.93)
Regularly active	22 576	3 632	0.83 (0.80 to 0.86)	0.88 (0.85 to 0.91)
CVD mortality				
No sport or exercise	120 325	6 921	1.00 (Reference)	1.00 (Reference)
Weekend warrior	11 981	533	0.91 (0.84 to 1.00)	0.94 (0.86 to 1.03)
Regularly active	22 576	1 296	0.90 (0.85 to 0.95)	0.93 (0.87 to 0.99)
Cancer mortality				
No sport or exercise	120 325	2 673	1.00 (Reference)	1.00 (Reference)
Weekend warrior	11 981	207	0.82 (0.71 to 0.95)	0.82 (0.71 to 0.95)
Regularly active	22 576	529	0.97 (0.88 to 1.06)	0.94 (0.86 to 1.04)

*Fully adjusted model was adjusted for age, sex, education, income, smoking, fruit and vegetable intake, and alcohol. Participants who died during the first 2 years of follow-up were removed. Values are HR (95% CIs). CVD, cardiovascular disease.

Table 3 Associations of physical activity patterns at baseline with all-cause mortality risk, stratified by the length of time spent exercising at each session*

Physical activity pattern	N	Deaths	Adjusted for age and sex	Fully adjusted
<30 min per session of sport or exercise				
No sport or exercise	120325	20791	1.00 (Reference)	1.00 (Reference)
Weekend warrior	2212	422	1.01 (0.92 to 1.12)	1.03 (0.94 to 1.14)
Regularly active	5307	1120	0.91 (0.86 to 0.97)	0.95 (0.89 to 1.01)
30–60 min per session of sport or exercise				
No sport or exercise	120325	20791	1.00 (Reference)	1.00 (Reference)
Weekend warrior	4977	640	0.80 (0.74 to 0.87)	0.84 (0.78 to 0.91)
Regularly active	10360	1586	0.84 (0.79 to 0.88)	0.88 (0.84 to 0.93)
>60 min per session of sport or exercise				
No sport or exercise	120325	20791	1.00 (Reference)	1.00 (Reference)
Weekend warrior	4794	521	0.76 (0.70 to 0.83)	0.82 (0.75 to 0.89)
Regularly active	6925	932	0.76 (0.71 to 0.81)	0.80 (0.75 to 0.86)

*Fully adjusted model was adjusted for age, sex, education, income, smoking, fruit and vegetable intake, and alcohol. Participants who died during the first 2 years of follow-up were removed. Values are HR (95% CIs).

Table 5 shows associations of physical activity patterns with all-cause mortality risk using repeated measures of physical activity and potential confounders. Participants were followed for 19.7 ± 1.9 years and there were a total of 843 deaths during 195 580 person-years of follow-up. Compared with being inactive or becoming inactive, the HR (95% CI) was 0.86 (0.65 to 1.12) when being a weekend warrior or becoming a weekend warrior and 0.85 (95% CI 0.70 to 1.03) when being regularly active or becoming regularly active.

DISCUSSION

The main objective of this study was to investigate associations of the weekend warrior physical activity pattern with mortality 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 mortality risks. In what are novel findings, we also found that, for both the weekend warrior pattern and the regularly active pattern, substantial reductions in risk only occurred when the duration of exercise sessions was at least 30–60 min. The secondary objective was to investigate associations of physical activity patterns with mortality using repeated measures of physical activity and potential confounders. We found that physical activity patterns changed considerably over time. In what are also novel findings, we found some evidence that being a weekend warrior or becoming a weekend warrior and being regularly active or becoming regularly active were associated with reduced risk of mortality.

Novelty and importance

To the best of our knowledge, this is the first study of the associations of the weekend warrior physical activity pattern with

mortality in Mexico or any other low-income to middle-income country in Latin America. The Mexico City Prospective Study is also one of the few cohort studies anywhere in the world to include repeated measures of physical activity and potential confounders.^{28–30} In 2004, Lee *et al* first investigated the benefits of the weekend warrior physical activity pattern in a relatively small study in the USA.⁴⁴ More recently, O'Donovan *et al* investigated associations of physical activity patterns with mortality in more than 63 000 adults in England and Scotland.¹³ They found that all-cause mortality risk was around 30% lower in weekend warriors and in the regularly active, whether or not they met prevailing physical activity guidelines.¹³ More recently still, Inoue *et al* investigated associations of daily step patterns with mortality in more than 3000 adults in the USA.⁴⁵ They found that all-cause mortality risk was lower in those who accumulated at least 8000 steps on 1 or 2 days per week compared with those who never took 8000 steps per day.⁴⁵ The present study is important because findings from high-income countries in Europe and North America may not be generalisable to low-income to middle-income countries in Latin America.

The present study suggests that all-cause mortality risk is around 15% lower in exercisers than in non-exercisers. In contrast, large studies in high-income countries in Europe and North America suggest that all-cause mortality risk is around 30% lower in exercisers than in non-exercisers.⁴⁶ 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^{4–6 8 9} and other low-income and middle-income regions.⁷ For example,

Table 5 Associations of physical activity patterns with all-cause mortality risk using repeated measures of physical activity and potential confounders*

Physical activity pattern	N	Deaths	HR (95% CI)
No sport or exercise	8008	685	1.00 (Reference)
Weekend warrior	502	51	0.86 (0.65 to 1.12)
Regularly active	1513	107	0.85 (0.70 to 1.03)

*This analysis only included participants who were resurveyed. The analysis included baseline measures of age and sex as well as baseline and resurvey measures of physical activity, education, income, smoking, fruit and vegetable intake, and alcohol. The analysis included all the available data for each variable, whether the data were available at baseline, resurvey or both. Robust estimates of variance were used to obtain the CI.

Table 4 Physical activity patterns at baseline and resurvey

Baseline	Resurvey			Total
	No sport or exercise	Weekend warrior	Regularly active	
No sport or exercise	6688	318	930	7936
Weekend warrior	474	100	152	726
Regularly active	847	85	432	1364
Total	8009	503	1514	10026

if the non-exercise group was 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 high-income countries. Indeed, Lear *et al* found that moderate and high levels of exercise were associated with reduced risk of mortality and major CVD events in high-income and upper-middle-income countries, but not in lower-middle-income and low-income countries where people took part in high amounts of non-exercise physical activity.⁴² The present study also suggests that there is a substantial reduction in cancer mortality risk in weekend warriors and little or no reduction in the regularly active. These results should be interpreted with caution because of the relatively low number of cancer deaths and because other large studies suggest that different physical activity patterns are associated with reduced risk of cancer mortality.^{12 13 41 46}

Very few cohort studies include repeated measures of physical activity.^{28–31} The present study suggests that people in Latin America can become more active. Large studies in high-income countries in Europe and North America also suggest that physical activity is amenable to change.^{29 31} For example, Bredablik *et al* investigated changes in physical activity across four waves of the HUNT Study in Norway.³¹ When physical activity was defined as 60 min per week, 8% of participants were persistently inactive, 15% were persistently active and 77% had a mixed pattern.³¹ When physical activity was defined as 150 min per week, 32% were persistently inactive, 2% were persistently active and 65% had a mixed pattern.³¹ Bredablik *et al* also found that mortality risk was reduced in those who became active, whether physical activity was defined as 60 or 150 min per week.³¹ To the best of our knowledge, the present study is the first study to provide some evidence that becoming a weekend warrior is associated with reduced risk of mortality. Leisure-time physical activity volume was not assessed in the present study, but studies in high-income countries in Europe and North America suggest that the dose–response relationship between leisure-time physical activity and mortality is curvilinear, where performing any level of activity is associated with a 20% lower risk of mortality and performing 3–10 times the recommended level is associated with a threshold of 39% lower risk of mortality.⁴⁶ More research is required to determine the nature of the dose–response relationship between leisure-time physical activity volume and mortality in Latin America.

Policy implications

The present study has important implications for policy and practice. Lack of time is probably the major barrier to participation in sport and exercise in Latin America^{15 17 18} and as many as 8 out of 10 adults in the region say they would like to do more sport.¹⁸ Twice as many participants were weekend warriors in the present study compared with large studies in high-income countries in Europe and North America (8% vs 3%–4%)^{12 13} and it is reasonable to suggest that more people in Latin America would exercise if they knew that taking part in one or two sessions per week was associated with considerable health benefits. Latin America is home to the Ciclovía Recreativa,^{19 47} which is the best large-scale physical activity intervention that we know of. Every Sunday, roads are closed to motor vehicles in dozens of cities in Latin America and the streets fill with walkers, runners and cyclists.^{19 47} In Mexico City, for example, more than 50 km of roads are closed to motor vehicles on Sundays and around 80 000 people enjoy being physically active in a safe and free-of-charge environment.^{23 48} In Bogotá in Colombia, more than

120 km of roads are closed every Sunday and public holiday and more than one million people take part in the Ciclovía Recreativa.⁴⁹ Surveys in Mexico City²³ and Bogotá²² suggest that most of these weekend warriors would not exercise if it were not for the Ciclovía Recreativa. Men were more likely to be weekend warriors in the present study and surveys suggest that males are more likely to take part in the Ciclovía Recreativa than females^{20 21}; however, the proportion of female participants can be increased by offering complementary aerobics classes and dance classes in nearby parks and public spaces.⁵⁰ People in the highest income tertile were more likely to be weekend warriors in the present study and surveys suggest that people in middle and high socioeconomic groups are more likely to take part in the Ciclovía Recreativa than people in low socioeconomic groups²¹; however, the proportion of low socioeconomic participants can be increased by including different neighbourhoods in the route.²¹ For example, the Ciclovía Recreativa in the city of Santiago in Chile takes place in high socioeconomic neighbourhoods and less than 10% of participants are of low socioeconomic status.²¹ In contrast, the interventions in the cities of Bogotá and Cali in Colombia take place in low, middle and high socioeconomic neighbourhoods and more than 20% of participants are of low socioeconomic status.²¹ Accelerometer studies in high-income countries in Europe suggest that taking part in two or three 1 or 2 min bouts of physical activity per day is sufficient to reduce mortality risk.⁵¹ However, more research is required to determine the benefits of non-exercise activity in Latin America, where levels of non-exercise activity are much higher.^{6 7}

Limitations

This study has strengths and limitations. The Mexico City Prospective Study is broadly representative of the population aged 35 years or older in Mexico City.²⁶ The present investigation included more than 150 000 cohort members and the analyses were adjusted for major confounders.^{40–42} Analyses were not adjusted for the dose of leisure-time physical activity (where the dose is the product of frequency×intensity×duration), but the available evidence suggests that the benefits of a given amount of physical activity are much the same whether performed on the weekend or spread over the week.¹² For example, Dos Santos *et al* investigated more than 350 000 adults in the USA and found that the HRs for all-cause mortality, CVD mortality and cancer mortality were similar in weekend warriors and the regularly active after adjusting for the dose of leisure-time physical activity.¹² Participants who died during the first 2 years of follow-up were removed to minimise the possibility of reverse causation. Physical activity and potential confounders were assessed at baseline and, unusually, after around 16 years in a subsample of more than 10 000 adults. The sample size in the main analysis was large enough to give precise estimates of the associations between physical activity and mortality, as indicated by the relatively narrow confidence intervals. The sample size in the repeated-measures analysis was not large enough to give precise estimates of the associations between changes in physical activity and mortality, as indicated by the relatively wide confidence intervals. Physical activity and other variables were self-reported, which may introduce recall bias, social desirability bias and other biases. Questionnaires were used to assess physical activity, but it is preferable that both questionnaires and accelerometers be used to assess physical activity in cohort studies because each method has advantages and disadvantages.^{52–54} Three simple questions were used to assess physical activity in the present study, but such simple assessment tools have been

validated against multiple-item physical activity assessment tools³⁶ and against cardiorespiratory fitness.³⁷ The assessment of diet quality was relatively simple, but relatively sophisticated assessments suggest that the benefits of physical activity are largely independent of the confounding effects of diet quality.⁴² This study provides clear evidence that the weekend warrior physical activity pattern and the regularly active physical activity pattern are beneficial to health in adults in Mexico. However, it is important to gather evidence from other countries in Latin America because there are great differences in income,⁵⁵ health⁵⁶ and healthcare⁵⁷ in the region.

CONCLUSIONS

To the best of our knowledge, the Mexico City Prospective Study is the largest cohort study in Mexico or elsewhere in Latin America. The study is also one of the few cohort studies anywhere in the world to include repeated measures of physical activity and potential confounders. Participants who died during the first 2 years of follow-up were removed to minimise the possibility of reverse causation. The analyses were adjusted for major confounders and the main results were robust to further adjustment for diabetes, hypertension, heart attack, stroke and cancer. The present analysis provides clear evidence that participation in sport and exercise is associated with health benefits in adults in Mexico. Both the weekend warrior physical activity pattern and the regularly active physical activity pattern were associated with reduced risk of mortality. In what are novel findings, we found that, for both the weekend warrior pattern and the regularly active pattern, substantial reductions in risk only occurred when the duration of exercise sessions was at least 30–60 min. In what are also novel findings, in the repeated measures analysis, we found some evidence that being a weekend warrior or becoming a weekend warrior were associated with reduced risk of mortality. There are high levels of non-exercise physical activity in many cities in Latin America and this study is important because it suggests that even the busy people of Mexico City could benefit from taking part in one or two sessions of sport and exercise per week.

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Acknowledgements This research has been conducted using Mexico City Prospective Study (MCPS) Data under Application Number 2022-015. MCPS (<https://www.ctsu.ox.ac.uk/research/mcps>) has received funding from the Mexican Health Ministry, the National Council of Science and Technology for Mexico, Wellcome and core grants from the UK Medical Research Council to the MRC Population Health Research Unit at the University of Oxford.

Contributors GO'D had a role in conceptualisation, formal analysis, writing the original draft and editing the drafts. FP-R, GF, I-M, MH, ES, OLS, AI and PL-J had a role in reviewing and editing. GO'D is the guarantor.

Funding AI is partially supported by grants from ANID/FONDECYT Regular (1210195 and 1210176 and 1220995); ANID/FONDAP/15150012; ANID/PIA/ANILLOS ACT210096; FONDEF ID20110152, ID22110029; ANID/FONDAP 15150012; Takeda CW2680521 and the Multi-partner consortium to expand dementia research in Latin America (ReDLat, supported by Fogarty International Center (FIC) and National Institutes of Health, National Institutes of Aging (R01 AG057234, R01 AG075775, R01 AG21051, CARDS-NIH), Alzheimer's Association (SG-20-725707), Rainwater Charitable foundation—Tau Consortium, the Bluefield Project to Cure Frontotemporal Dementia and Global Brain Health Institute)).

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and the study was approved by the Mexican Ministry of Health, the Mexican National Council of Science and Technology (approval number 0595 P-M), and the Central Oxford Research Ethics Committee (C99.260). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Mexico City Prospective Study data are available for open-access data requests. The data access policy is described online: <http://www.ctsu.ox.ac.uk/research/mcps>.

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Associations of the 'weekend warrior' physical activity pattern with all-cause, cardiovascular disease, and cancer mortality: the Mexico City Prospective Study

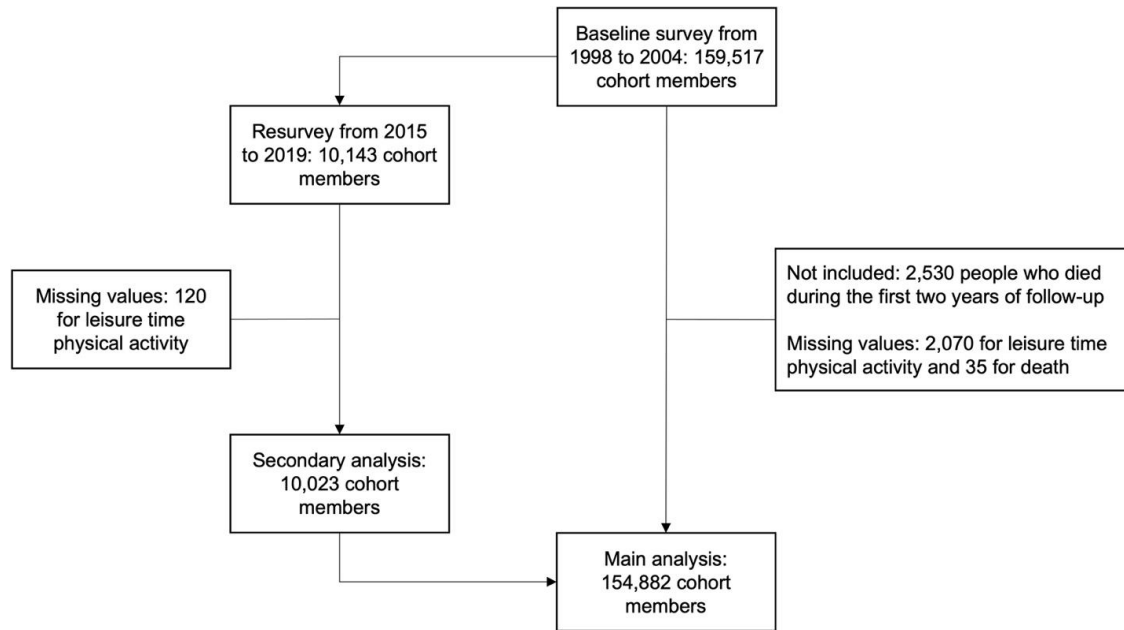


Figure S1. Flow of participants through the study. The main analysis was a single-measure design and included 154,882 of 159,517 (97%) cohort members. The secondary analysis was a repeated-measures design and included 10,023 of 10,143 (99%) cohort members who were resurveyed. Mortality was tracked to December 2020. The duration of follow-up was 17.6±4.0 years (mean±SD) in the main analysis and 19.7±1.9 years in the secondary analysis.

Table S1. Associations of physical activity patterns with all-cause mortality, with further adjustment for self-reported illnesses*

Physical activity pattern	N	Deaths	Adjusted for age and sex	Fully-adjusted
No sport or exercise	120,325	20,791	1.00 (Reference)	1.00 (Reference)
Weekend Warrior	11,981	1,583	0.84 (0.80, 0.88)	0.89 (0.85, 0.94)
Regularly active	22,576	3,632	0.83 (0.80, 0.86)	0.87 (0.84, 0.90)

*The fully-adjusted model was adjusted for age, sex, education, income, smoking, fruit and vegetable intake, alcohol, diabetes, hypertension, heart attack, stroke, and cancer. Participants who died during the first two years of follow-up were removed. Values are hazard ratio (95% confidence interval).