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Trajectories of physical activity patterns across the life course in Mexican adults: findings from the Mexico city prospective study

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Abstract

Objective The present study aimed to identify factors associated with distinct trajectories of physical activity (PA) patterns in Mexican adults during a 16-year follow-up.

Methods We included 9,958 adults aged 35 years or older enrolled in The Mexico City Prospective Study, a prospective cohort study conducted from 1998 to 2004 to 2015–2019. PA was assessed through self-reported questionnaires and categorized into three patterns: inactive, weekend warrior, and regularly active. PA pattern trajectories were derived from the two assessment periods and classified into four categories: inactive stable, decreased, increased/weekend warrior stable and regularly active stable. Sociodemographic characteristics, nutritional status, lifestyle factors, and health history were collected at baseline.

Results Of the total sample, 66.7% were inactive stable, 14% decreased, 15% increased/weekend warriors stable, and 4.3% regularly active stable. Results revealed that women (OR = 1.75, 95%CI: 1.33–2.30), no educational level (OR = 14.72, 95%CI: 5.83–37.15) and obesity (OR = 1.75, 95%CI: 1.48–2.08) were associated with higher odds of being inactive stable. Among women, middle-aged was associated with lower odds of being inactive stable (OR = 0.71; 95%CI: 0.53–0.95), while no educational level (OR = 20.69; 95%CI: 6.25–68.52), obesity (OR = 1.91; 95%CI: 1.45–2.51), fruit and vegetable consumption “<5x/week” (OR = 2.05; 95%CI: 1.53–2.74) were associated with greater odds of being inactive stable. For men, no educational level (OR = 7.30; 95%CI: 1.65–32.25), fruit and vegetable consumption “<5x/week” (OR = 2.73; 95%CI: 1.91–3.90) were associated with higher odds of being inactive stable.

Conclusion Sex, age, education level, obesity, and fruit and vegetable consumption were associated with distinct trajectories of PA patterns. The factors associated with these trajectories varied by sex.

Keywords Physical activity, Longitudinal, Prospective, Trajectory

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Introduction

Regular physical activity (PA) is an important health behavior that contributes to preventing chronic diseases and reducing mortality risk [1]. Despite its health benefits, reducing physical inactivity in the adult population has been a major challenge for public health policies [2]. It is estimated that one-third of the global population does not meet PA recommendations, and most countries are far from achieving the goal of reducing physical inactivity to 15% by 2030 [3]. In Latin America, the situation is even more concerning because the region exhibits an average prevalence above the global average (31.3% vs. 36.6%) and shows a high disparity between age and sex [3]. Data from national surveys in Mexico, the second most populous country in Latin America, indicate a significant increase in inactive individuals from 2006 to 2018, rising from 14 to 20.8% [4].

Physical inactivity is responsible for approximately 7% of all deaths and up to 8% of non-communicable chronic diseases worldwide, with the highest number of individuals living in middle-income countries, such as Mexico [5]. Physical inactivity also represents a significant economic and health burden on public finances [2]. However, to bring about changes in the population, public policies that encourage and facilitate PA are necessary [6]. Identifying sociodemographic characteristics and lifestyle factors within a population that may be associated with changes in this behavior over the life course is essential to guide and enhance public policies in countries [6, 7].

It is known that physical inactivity tends to increase with age [8]. However, other factors may be associated with PA trajectories throughout life [9]. A systematic review of longitudinal studies that tracked PA trajectories showed that the most commonly analyzed factors are socioeconomic status, family or social support, sociodemographic characteristics, health behaviors, and health-related variables [9]. Having a higher income or a healthier diet has also been associated with an increased likelihood of maintaining an active trajectory while smoking or having a diagnosis of chronic diseases has been associated with a decline in PA over time [9].

The trajectory of PA and its related factors is still a novel area of research [9]. Therefore, there is still a need for studies to expand the evidence base on the topic. Furthermore, all studies included in the review were conducted in high-income countries (in Europe, the USA, Canada, Australia, or Taiwan), and identifying PA trajectories in countries beyond the world's leading economies is a gap that needs to be addressed [9]. The present study aimed to identify factors associated with distinct trajectories of PA patterns in Mexican adults during a 16-year follow-up.

Methods

Study design and sample

The Mexico City Prospective Study is a prospective observational study with a sample of Mexican adults, conducted in the capital (Mexico City) and two neighboring districts (Coyoacán and Iztapalapa). More details about the study and methodological procedures can be found in a separate publication [10]. In summary, the study was conducted with the support of the Mexican Ministry of Health, the Oxford Clinical Trial Service Unit (CTSUs), and the UK Wellcome Trust. All data were collected in participants' homes by previously trained nurses, and the data used in this report were obtained through an open-access data request made to the lead investigators of the Mexico City Prospective Study. The study involved over 150,000 Mexican adults aged 35 or older at the time of evaluation. The baseline occurred between 1998 and 2004, and the resurvey between 2015 and 2019.

A total of 159,517 individuals participated in the study. We excluded participants who did not participate in the resurvey ($n = 149,374$), those without PA data at baseline and resurvey ($n = 117$), and those without baseline data on the variables considered in this study ($n = 68$). Our final analytical sample included 9,958 participants (age range: 35 to 96 years) with an average follow-up time of 16.19 ± 2.12 years (mean $\pm$ SD) between the baseline and resurvey.

Ethics approval

The study followed the Declaration of Helsinki guidelines for research on human beings and was approved by the scientific and ethics committees within the Mexican National Council of Science and Technology (approval number 0595 P-M), the Mexican Ministry of Health, and the Central Oxford Research Ethics Committee (C99.260). Participants gave informed consent before taking part in the study.

Assessment of the pattern and trajectory of physical activity

This assessment focused on characterizing the frequency and patterns of PA accumulation over time, rather than measuring its volume or intensity. PA was assessed through questionnaires. During the baseline, participants were asked whether they engaged in exercise or sports (yes or no) and how often they performed PA per week (less than once a week, one or two times per week, or three or more times per week). Sixteen years later, during the resurvey, participants were again asked whether they exercised or played sports (yes/no) and how many days per week they exercised (open numeric response). Although the question formats differed slightly between assessments (categorical at baseline versus continuous at

resurvey), both referred to the same core domains of PA. Individuals were categorized into three groups according to their PA pattern: “inactive” (no exercise or sports), “weekend warrior” (engaging in exercise or sports up to one or two times per week), and “regularly active” (engaging in exercise or sports three or more times per week) [10, 11]. It is important to note that the “weekend warrior” category in this study refers solely to individuals reporting 1–2 sessions per week, regardless of duration or intensity, and does not imply compliance with PA guidelines [11]. These questions have demonstrated acceptable validity and good reproducibility in previous analyses within the Mexico City Prospective Study cohort and other population-based studies [11–13].

Based on the pattern of PA reported baseline and resurvey, PA trajectory was categorized as follows: “inactive stable” (inactive at both evaluation points), “decreased” (regularly active to weekend warrior or inactive; weekend warrior to inactive), “increased/weekend warrior stable” (inactive to weekend warrior or regularly active; weekend warrior at baseline and resurvey; weekend warrior to regularly active), and “regularly active stable” (regularly active at baseline and resurvey) [14].

Covariates

Covariates were self-reported at baseline. Age was reported and categorized as “adult” (19–44 years), “middle age” (45–64 years), or “older adult” (65 years or older). Marital status was classified as “not married” (single, divorced, separated, or widowed) or “married/cohabiting” (living together or married). Educational level was classified as: “no,” “incomplete primary,” “complete primary,” “secondary,” and “tertiary education” [15]. Income, measured in Pesos/week, was categorized into three tertiles [16]. Tertile 1 ranged from 0 to 0 Pesos/week (median: 0; Interquartile Range [IQR]: 0–0), tertile 2 from 4 to 1200 Pesos/week (median: 900; IQR: 500–1050), and tertile 3 from 1225 to 90,000 Pesos/week (median: 2500; IQR: 2000–4000).

Height (measured with a wooden triangle and a 3 m long measuring tape) and weight (measured using portable analogue scales) were obtained [10]. Body mass index (BMI) was calculated using the formula $BMI = \text{weight (kg)} / \text{height (m)}^2$ and classified as “obese” (≥ 30.0) or “non-obese” (< 30.0) [17].

Alcohol consumption was classified as “current drinkers” (up to 3 times a month, up to 2 times a week, or 3 or more times a week) or “abstainers” (never or former) [18]. Smoking behavior was categorized as “current smoker” (less than daily, less than 10/day, or more than 10/day) or “not smoking” (never or former quit – more than 3 years ago) [19]. Fruit and vegetable consumption as “ $< 5x/\text{week}$ ” or “ $> 5x/\text{week}$ ”, and sleep time as “inadequate” or

“adequate” (7–9 h for adults and 7–8 h for older adults) [20, 21].

Participants also provided self-reported information on medical diagnoses related to 17 diseases, including emphysema, heart attack, angina, asthma, stroke, chronic kidney disease, peptic ulcer, cirrhosis, hypertension, diabetes, various types of cancer, and peripheral artery disease [10]. The responses were classified as “no disease,” “at least one disease,” or “two or more diseases.”

Statistical analysis

The categorization of the dependent variable representing PA trajectories was determined through a comparative model selection process. This process involved testing alternative conceptual groupings of the PA patterns (i.e., different ways of classifying individuals into trajectory groups based on their PA patterns at baseline and resurvey). We utilized the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) to evaluate these alternative models [14, 22]. The categorization that yielded the lowest AIC and BIC values, indicating the optimal balance of model fit and parsimony, was chosen as the most appropriate. This approach enabled us to identify the most robust and interpretable set of distinct PA trajectories.

Descriptive characteristics of the sample were presented using frequency and percentage. Multivariable multinomial logistic regression models were performed to estimate Odds Ratio (OR) and 95% confidence interval (95%CI) for the factors (independent variables) associated with distinct PA patterns trajectories (dependent variable) [14, 23]. The dependent variable was PA pattern trajectory, categorized as inactive stable, decreased, and increased/weekend warrior stable, with regularly active stable as the reference category. Given the relatively smaller size of the “regularly active stable” reference category, robustness analyses were performed using alternative reference groups, with results consistently supporting the main findings (Additional File 1). Factors included in the model were sex, age, marital status, educational level, income, nutritional status, alcohol consumption, smoking behavior, fruit and vegetable consumption, sleep time, and disease history. We also performed stratified by sex, given the consistent evidence that men and women differ in their PA levels [24], as well as in the psychosocial, cultural, and environmental determinants that influence these behaviors [25–28]. This stratification allows for a more accurate interpretation of sex-specific factors associated with PA trajectories and is supported by prior literature [12, 24, 25]. A sensitivity analysis was performed to compare the characteristics of the initial and final samples, utilizing Chi-Squared tests to investigate potential differences in representativeness due to sample attrition. Variance Inflation Factor (VIF)

values (acceptable if <10) and tolerance levels (acceptable if >0.25) were analyzed to evaluate multicollinearity among the independent variables. The level of significance was set at $P \leq 0.05$. All statistical analyses were performed using SPSS V22 software (SPSS Inc., IBM Corp., Armonk, New York, NY, USA).

Results

Given the significant sample loss of approximately 93.7%, a sensitivity analysis was conducted to investigate the impact of this loss on the representativeness of the final

sample in relation to the characteristics of the initial population (Additional file 2).

The study population consisted of 9,958 individuals (70% women). Table 1 presents the characteristics of the population at baseline, with 54.2% classified as middle-aged, 75.4% married/cohabiting, 24.6% not married, 5.9% with no educational level, 48.7% in tertile 1, 40.2% obese, 67.9% current drinkers, 29.5% current smokers, 44.4% fruit and vegetable consumption “ $<5x/week$ ”, 32% with inadequate sleep time and 7.9% with two or more diseases.

Table 1 Baseline characteristics [N(%)] of participants by trajectories of physical activity patterns

Characteristics	Total 9958 (100.0)	Inactive stable 6639 (66.7)	Decreased 1397 (14.0)	Increased/weekend warrior stable 1492 (15.0)	Regularly active stable 430 (4.3)
Sex					
Men	2985 (30.0)	1727 (26.0)	572 (40.9)	526 (35.3)	160 (37.2)
Women	6973 (70.0)	4912 (74.0)	825 (59.1)	966 (64.7)	270 (62.8)
Age					
Adult (19–44)	3226 (32.4)	2071 (31.2)	406 (29.1)	593 (39.7)	156 (36.3)
Middle age (45–64)	5399 (54.2)	3589 (54.1)	755 (54.0)	816 (54.7)	239 (55.6)
Older adult (≥ 65)	1333 (13.4)	979 (14.7)	236 (16.9)	83 (5.6)	35 (8.1)
Marital status					
Married/cohabiting	7508 (75.4)	4958 (74.7)	1037 (74.2)	1177 (78.9)	336 (78.1)
Not married	2450 (24.6)	1681 (25.3)	360 (25.8)	315 (21.1)	94 (21.9)
Educational level					
Tertiary	1163 (11.6)	552 (8.3)	241 (17.3)	266 (17.8)	104 (24.2)
Secondary	2329 (23.4)	1422 (21.4)	391 (28.0)	376 (25.2)	140 (32.6)
Complete primary	3052 (30.6)	2035 (30.7)	408 (29.2)	488 (32.7)	121 (28.1)
Incomplete primary	2825 (28.4)	2115 (31.9)	315 (22.5)	335 (22.5)	60 (14.0)
No	589 (5.9)	515 (7.8)	42 (3.0)	27 (1.8)	5 (1.2)
Income					
Tertile 3	3273 (32.9)	1926 (29.0)	575 (41.2)	594 (39.8)	178 (41.4)
Tertile 2	1840 (18.5)	1298 (19.6)	227 (16.2)	257 (17.2)	58 (13.5)
Tertile 1	4845 (48.7)	3415 (51.4)	595 (42.6)	641 (43.0)	194 (45.1)
Nutritional status					
Non-obese (<30.0)	5957 (59.8)	3780 (56.9)	922 (66.0)	943 (63.2)	312 (72.6)
Obese (≥ 30.0)	4001 (40.2)	2859 (43.1)	475 (34.0)	579 (36.8)	118 (27.4)
Alcohol consumption					
Abstainers	3196 (32.1)	2276 (34.3)	372 (26.6)	434 (29.1)	114 (26.5)
Current drinkers	6762 (67.9)	4363 (65.7)	1025 (73.4)	1058 (70.9)	316 (73.5)
Smoking behaviour					
Not smoking	7016 (70.5)	4744 (71.5)	945 (67.6)	1027 (68.8)	300 (69.8)
Current smoker	2942 (29.5)	1895 (28.5)	452 (32.4)	465 (31.2)	130 (30.2)
Fruit and vegetable consumption					
$\geq 5x/week$	5538 (55.6)	3477 (52.4)	894 (64.0)	852 (57.1)	315 (73.3)
$<5x/week$	4420 (44.4)	3162 (47.6)	503 (36.0)	640 (42.9)	115 (26.7)
Sleep time					
Adequate	6776 (68.0)	4505 (67.9)	912 (65.3)	1045 (70.0)	314 (73.0)
Inadequate	3182 (32.0)	2134 (32.1)	485 (34.7)	447 (30.0)	116 (27.0)
Disease history					
No disease	6515 (65.4)	4310 (64.9)	842 (60.3)	1075 (72.1)	288 (67.0)
At least one disease	2657 (26.7)	1798 (27.1)	415 (29.7)	334 (22.4)	110 (25.6)
Two or more diseases	786 (7.9)	531 (8.0)	140 (10.0)	83 (5.5)	32 (7.4)

Figure 1 shows the trajectories of PA patterns during the 16-year follow-up. Of the total sample, 66.7% were inactive stable, 14.0% decreased, 15.0% increased/week-end warriors stable and 4.3% were regularly active stable. Data on the proportions of PA trajectories between baseline and resurvey among Mexican adults, as well as the proportions of inactive, weekend warrior, and regularly active individuals during these periods, with information for the total population and separated by sex, are provided as supplementary material (Additional file 3 and Additional file 4).

Table 2 shows the results of the multivariable multinomial regression models for the factors associated with distinct trajectories of PA patterns (regularly active stable group was considered as the reference group). Being woman (OR=1.75, 95%CI: 1.33–2.30), having no educational level (OR=14.72, 95%CI: 5.83–37.15), obesity (OR=1.75, 95%CI: 1.40–2.18) and consuming fruit and vegetable “<5x/week” (OR=2.32, 95%CI: 1.85–2.90) were associated with increased odds of inactive stable trajectory. Older adults (OR=1.82, 95%CI: 1.17–2.83), no educational level (OR=3.02, 95%CI: 1.14–8.03), obesity (OR=1.33, 95%CI: 1.04–1.69), fruit and vegetable consumption “<5x/week” (OR=1.46, 95%CI: 1.14–1.86) and inadequate sleep time (OR=1.31, 95%CI: 1.03–1.67) were associated with increased odds of decreased trajectory. Having incomplete or complete primary (OR=2.49, 95%CI: 1.68–3.69 and OR=1.69, 95%CI:

1.22–2.34, respectively), being obese (OR=1.49, 95%CI: 1.17–1.90), and consuming fruit and vegetable “<5x/week” (OR=1.92, 95%CI: 1.51–2.45) were associated with higher odds of increased/weekend warrior stable trajectories.

Tables 3 and 4 present the results stratified by sex. Among women, middle age (OR=0.71, 95%CI: 0.53–0.95), no educational level (OR=20.69, 95%CI: 6.25–68.52), obesity (OR=1.91, 95%CI: 1.45–2.51) and fruit and vegetable consumption “<5x/week” (OR=2.05, 95%CI: 1.53–2.74) were associated with higher odds of inactive stable trajectory. Older adult women (OR=2.38, 95%CI: 1.32–4.30) and no educational level (OR=4.16, 95%CI: 1.19–14.54) showed a higher odds of decreased trajectory. Older adult (OR=0.33, 95%CI: 0.17–0.64), incomplete or complete primary (OR=2.32, 95%CI: 1.40–3.84 and OR=1.55, 95%CI: 1.01–2.39, respectively), obesity (OR=1.49, 95%CI: 1.17–1.90) and fruit and vegetable consumption “<5x/week” (OR=1.92, 95%CI: 1.51–2.45) was associated with lower odds of increased/weekend warrior stable trajectories. Among men, no educational level (OR=7.30, 95%CI: 1.65–32.25) and fruit and vegetable consumption “<5x/week” (OR=2.73, 95%CI: 1.91–3.90) were associated with higher odds of inactive stable trajectory. Incomplete primary (OR=2.09, 95%CI: 1.09–4.02), fruit and vegetable consumption “<5x/week” (OR=1.81, 95%CI: 1.24–2.65) and sleep time inadequate (OR=1.49, 95%CI: 1.01–2.22) showed a higher odds

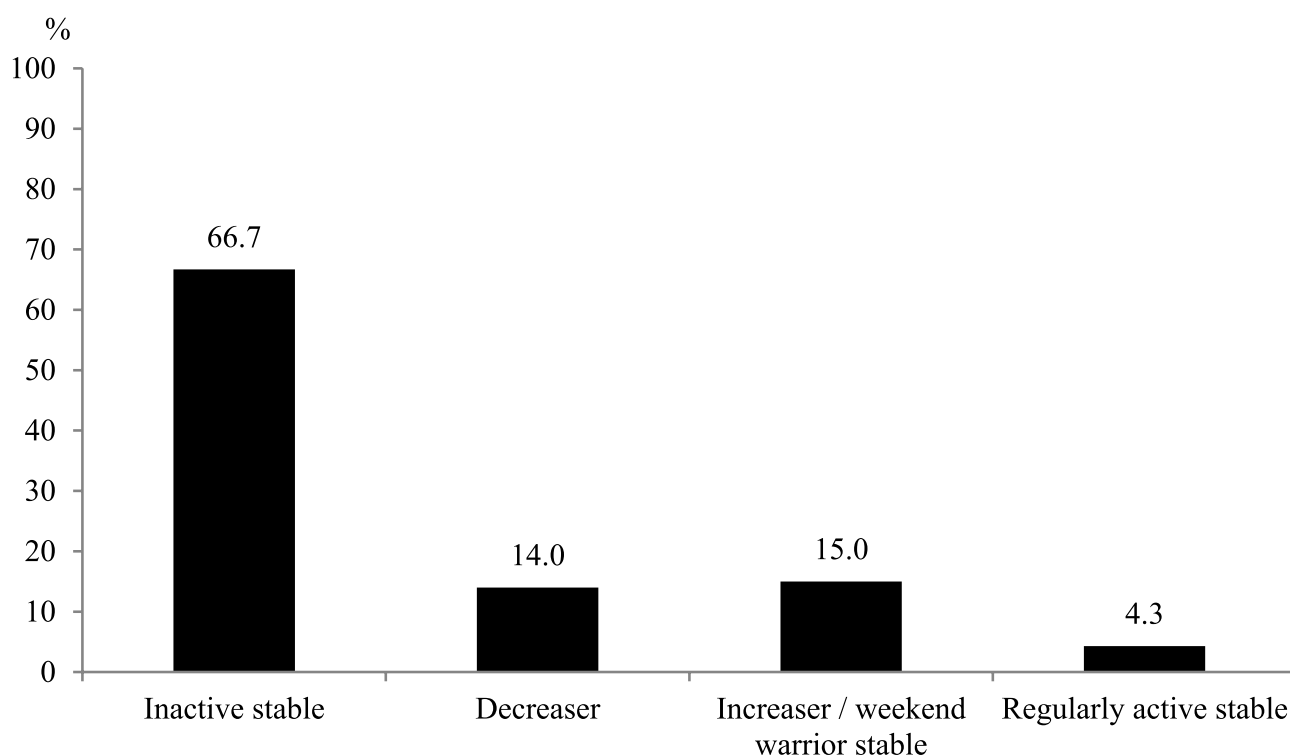


Fig. 1 Trajectories of physical activity patterns during the 16-year follow-up in Mexican adults

Table 2 Multivariable multinomial logistic regression of baseline characteristics associated with trajectories of physical activity patterns

	Inactive stable	Decreased	Increased/weekend warrior stable
Sex			
Men	1.00	1.00	1.00
Women	1.75 (1.33–2.30)	0.90 (0.67–1.21)	1.24 (0.92–1.67)
Age			
Adult (19–44)	1.00	1.00	1.00
Middle age (45–64)	0.81 (0.64–1.01)	1.01 (0.79–1.31)	0.77 (0.60–0.98)
Older adult (≥ 65)	1.16 (0.77–1.76)	1.82 (1.17–2.83)	0.48 (0.30–0.77)
Marital status			
Married/cohabiting	1.00	1.00	1.00
Not married	0.98 (0.76–1.25)	1.16 (0.88–1.52)	0.91 (0.69–1.20)
Educational level			
Tertiary	1.00	1.00	1.00
Secondary	1.73 (1.30–2.28)	1.22 (0.90–1.66)	1.04 (0.76–1.41)
Complete primary	2.84 (2.01–3.84)	1.41 (1.01–1.96)	1.69 (1.22–2.34)
Incomplete primary	5.58 (3.87–8.03)	1.93 (1.30–2.86)	2.49 (1.68–3.69)
No	14.72 (5.83–37.15)	3.02 (1.14–8.03)	2.45 (0.89–6.67)
Income			
Tertile 3	1.00	1.00	1.00
Tertile 2	1.11 (0.80–1.54)	0.97 (0.68–1.38)	1.05 (0.74–1.49)
Tertile 1	0.81 (0.61–1.06)	0.87 (0.64–1.18)	0.75 (0.55–1.01)
Nutritional status			
Non-obese (< 30.0)	1.00	1.00	1.00
Obese (≥ 30.0)	1.75 (1.40–2.18)	1.33 (1.04–1.69)	1.49 (1.17–1.90)
Alcohol consumption			
Abstainers	1.00	1.00	1.00
Current drinkers	0.83 (0.66–1.04)	1.05 (0.81–1.35)	0.91 (0.71–1.67)
Smoking behaviour			
Not smoking	1.00	1.00	1.00
Current smoker	1.21 (0.96–1.52)	1.14 (0.89–1.47)	1.03 (0.80–1.32)
Fruit and vegetable consumption			
≥ 5x/week	1.00	1.00	1.00
< 5x/week	2.32 (1.85–2.90)	1.46 (1.14–1.86)	1.92 (1.51–2.45)
Sleep time			
Adequate	1.00	1.00	1.00
Inadequate	1.21 (0.97–1.51)	1.31 (1.03–1.67)	1.18 (0.93–1.51)
Disease history			
No disease	1.00	1.00	1.00
At least one disease	0.86 (0.68–1.10)	1.14 (0.88–1.48)	0.79 (0.91–1.02)
Two or more diseases	0.81 (0.55–1.20)	1.28 (0.84–1.95)	0.68 (0.43–1.05)

Odds ratio (95% confidence interval)

Statistically significant results ($p \leq 0.05$) are highlighted in bold

The analysis was adjusted for: sex, age, marital status, educational level, income, nutritional status, alcohol consumption, smoking behavior, fruit and vegetable consumption, sleep time, and disease history; Reference = regularly active stable.

of decreased trajectory. Conversely, having incomplete or complete primary (OR = 1.82, 95%CI: 1.10–3.03 and OR = 2.68, 95%CI: 1.39–5.17, respectively) and fruit and vegetable consumption “< 5x/week” (OR = 2.07, 95%CI: 1.41–3.03) were associated with higher odds of increased or maintaining the weekend warrior stable trajectories.

Discussion

The present study aimed to identify factors associated with distinct trajectories of PA patterns in Mexican adults during a 16-year follow-up. We found that 66.7% of participants were inactive stable, while only 4.3% were regularly active stable. Our results show that being a woman, no education level, obesity, and fruit and vegetable consumption “< 5x/week” were associated with higher

Table 3 Multivariable multinomial logistic regression of baseline characteristics associated with trajectories of physical activity patterns in women

	Inactive stable	Decreased	Increased/weekend warrior stable
Age			
Adult (19–44)	1.00	1.00	1.00
Middle age (45–64)	0,71 (0,53 – 0,95)	1,17 (0,84 – 1,62)	0,68 (0,50 – 0,93)
Older adult (≥ 65)	1,03 (0,59 – 1,79)	2,38 (1,32 – 4,30)	0,33 (0,17 – 0,64)
Marital status			
Married/cohabiting	1.00	1.00	1.00
Not married	1,15 (0,85 – 1,57)	1,26 (0,90 – 1,77)	1,09 (0,78 – 1,53)
Educational level			
Tertiary	1.00	1.00	1.00
Secondary	1,73 (1,18 – 2,52)	1,10 (0,72 – 1,68)	0,96 (0,64 – 1,45)
Complete primary	3,08 (2,07 – 4,59)	1,42 (0,91 – 2,22)	1,55 (1,01 – 2,39)
Incomplete primary	5,71 (3,57 – 9,11)	1,80 (1,07 – 3,02)	2,32 (1,40 – 3,84)
No	20,69 (6,25 – 68,52)	4,16 (1,19 – 14,54)	3,14 (0,88 – 11,22)
Income			
Tertile 3	1.00	1.00	1.00
Tertile 2	1,06 (0,68 – 1,65)	0,95 (0,58 – 1,55)	0,92 (0,57 – 1,48)
Tertile 1	0,87 (0,62 – 1,23)	0,97 (0,66 – 1,42)	0,78 (0,54 – 1,13)
Nutritional status			
Non-obese (< 30.0)	1.00	1.00	1.00
Obese (≥ 30.0)	1,91 (1,45 – 2,51)	1,35 (1,00 – 1,82)	1,56 (1,16 – 2,09)
Alcohol consumption			
Abstainers	1.00	1.00	1.00
Current drinkers	0,84 (0,64 – 1,10)	1,09 (0,81 – 1,48)	0,92 (0,69 – 1,24)
Smoking behaviour			
Not smoking	1.00	1.00	1.00
Current smoker	1,14 (0,83 – 1,56)	1,23 (0,87 – 1,75)	1,12 (0,72 – 1,44)
Fruit and vegetable consumption			
≥ 5x/week	1.00	1.00	1.00
< 5x/week	2,05 (1,53 – 2,74)	1,22 (0,88 – 1,68)	1,79 (1,31 – 2,44)
Sleep time			
Adequate	1.00	1.00	1.00
Inadequate	1,10 (0,83 – 1,45)	1,21 (0,89 – 1,64)	1,16 (0,85 – 1,57)
Disease history			
No disease	1.00	1.00	1.00
At least one disease	0,85 (0,64 – 1,15)	1,20 (0,74 – 1,94)	0,79 (0,57 – 1,09)
Two or more diseases	0,74 (0,47 – 1,16)	1,21 (0,89 – 1,64)	0,71 (0,43 – 1,18)

Odds ratio (95% confidence interval)

Statistically significant results ($p \leq 0.05$) are highlighted in bold

The analysis was adjusted for: age, marital status, educational level, income, nutritional status, alcohol consumption, smoking behavior, fruit and vegetable consumption, sleep time, and disease history; Reference = regularly active stable.

odds of inactive stable trajectory. Older adults, no educational level, obesity, fruit and vegetable consumption “<5x/week,” and inadequate sleep time were associated with increased odds of decreased trajectory. The factors associated with these trajectories varied by sex.

Despite the Global Action Plan on PA launched in 2018 to reduce physical inactivity in the population by 15% by 2030, countries in Latin America seem to be moving in the opposite direction [3]. In the present study, most of the sample presented a PA trajectory as inactive stable (66.7%). These findings are concerning, as the

burden of physical inactivity incurs high economic and human costs [2]. The proportion of inactive individuals in the present study (baseline: 79.1% and resurvey: 79.9%) was considerably higher than the values found in the previous study [4], which analyzed results from three national surveys in Mexico from 2006 to 2018, reporting a prevalence of 20.8% of inactive individuals. Despite the different prevalence rates found, the authors also observed an increase in the prevalence of inactivity during the study period, rising from 14.0% in 2006 to 20.8% in 2018 [4]. These findings reinforce the urgent need for

Table 4 Multivariable multinomial logistic regression of baseline characteristics associated with trajectories of physical activity patterns in men

	Inactive stable	Decreased	Increased/ weekend warrior stable
Age			
Adult (19–44)	1.00	1.00	1.00
Middle age (45–64)	1.01 (0.68–1.49)	0.84 (0.56–1.28)	0.87 (0.27–1.32)
Older adult (≥ 65)	1.37 (0.71–2.63)	1.24 (0.62–2.47)	0.65 (0.32–1.34)
Marital status			
Married/cohabiting	1.00	1.00	1.00
Not married	0.78 (0.49–1.23)	0.97 (0.60–1.56)	0.69 (0.41–1.13)
Educational level			
Tertiary	1.00	1.00	1.00
Secondary	1.65 (1.08–2.54)	1.38 (0.87–2.17)	1.11 (0.69–1.77)
Complete primary	2.27 (1.41–3.64)	1.32 (0.80–2.19)	1.82 (1.10–3.03)
Incomplete primary	5.27 (2.85–9.74)	2.09 (1.09–4.02)	2.68 (1.39–5.17)
No	7.30 (1.65–32.25)	0.99 (0.18–5.51)	1.35 (0.24–7.53)
Income			
Tertile 3	1.00	1.00	1.00
Tertile 2	1.24 (0.75–2.05)	1.14 (0.67–1.95)	1.29 (0.75–2.21)
Tertile 1	0.67 (0.39–1.15)	0.68 (0.37–1.23)	0.72 (0.39–1.32)
Nutritional status			
Non-obese (< 30.0)	1.00	1.00	1.00
Obese (≥ 30.0)	1.43 (0.97–2.12)	1.21 (0.80–1.84)	1.38 (0.91–2.10)
Alcohol consumption			
Abstainers	1.00	1.00	1.00
Current drinkers	0.83 (0.54–1.29)	0.93 (0.58–1.49)	0.87 (0.54–1.40)
Smoking behaviour			
Not smoking	1.00	1.00	1.00
Current smoker	1.32 (0.94–1.85)	1.05 (0.73–1.51)	1.03 (0.71–1.48)
Fruit and vegetable consumption			
≥ 5x/week	1.00	1.00	1.00
< 5x/week	2.73 (1.91–3.90)	1.81 (1.24–2.65)	2.07 (1.41–3.03)
Sleep time			
Adequate	1.00	1.00	1.00
Inadequate	1.45 (0.99–2.11)	1.49 (1.01–2.22)	1.20 (0.80–1.79)
Disease history			
No disease	1.00	1.00	1.00

Table 4 (continued)

	Inactive stable	Decreased	Increased/ weekend warrior stable
At least one disease	0.91 (0.61–1.38)	1.06 (0.68–1.64)	0.80 (0.51–1.25)
Two or more diseases	1.21 (0.51–2.91)	1.54 (0.62–3.85)	0.59 (0.20–1.55)

Odds ratio (95% confidence interval)

Statistically significant results ($p \leq 0.05$) are highlighted in bold

The analysis was adjusted for: age, marital status, educational level, income, nutritional status, alcohol consumption, smoking behavior, fruit and vegetable consumption, sleep time, and disease history; Reference = regularly active stable

interventions to halt the rise of physical inactivity in the country. According to recent estimates, reducing physical inactivity in Mexico by 15% by 2030 could prevent over 17,100 cases of type 2 diabetes and 9,200 cases of coronary heart disease, in addition to various other diseases and deaths [29].

PA was measured through self-reported questionnaires. However, the National Health and Nutrition Survey used the short version of the International Physical Activity Questionnaire [4, 10]. The questionnaires include different questions about PA, which can lead to distinct interpretations by the respondents, and this may partly explain the varying proportions found [30].

Particularly in the Americas, women are less active than men [24]. The present study's results corroborate this finding. Despite a reduction in inactive women during the follow-up period, unlike what was observed among men, being a woman was a risk factor for being inactive stable. Other studies that analyzed PA trajectories, considering sex, found similar results [14, 31, 32]. Compared to men, women face various barriers to engaging in PA, including personal, environmental, and sociocultural factors that justify these findings [25–27]. Examples include domestic responsibilities that limit women's time for leisure PA, cultural prejudices related to women participating in more intense sports, lack of safety and infrastructure that allows for adequate practice for women, gender inequality in sports practices and opportunities, as well as biological and psychological factors [33, 34]. More public policies aimed at gender equity, with social incentives for this group and measures for educating and raising awareness in the population about the issue, could positively impact women's health. Studies that tracked women's PA trajectories for at least ten years reported that those with higher levels of PA during follow-up showed better bone health and physical performance [35, 36]. A study examined the trajectory of PA and medical and pharmaceutical costs in middle-aged Australian women over 12 years. It revealed that consistently inactive women had higher expenditures in these costs [37]. Another study, conducted in the United States,

which followed older adult women from 1994 to 2009, further revealed that not having a trajectory of physical inactivity, even with small amounts of PA, may be sufficient to reduce mortality risk [38].

Both women and men worldwide tend to decrease their PA with aging, despite the vast evidence regarding its importance in aging [24]. Following the literature, the present study found an increase in the odds of decreased PA among the older adult and lower odds of increasing or maintaining the weekend warrior pattern among middle-aged and older adults. When analyzed by sex, this association was observed among women but not among men. The older adult belongs to a risk group that naturally tends to experience declines in physical and cognitive health during the aging process. Still, PA can slow or attenuate this loss [39]. The older adult population in Mexico is growing rapidly, and data from 2020 show that this age group represented approximately 12% of the population, with estimates suggesting that this number will reach 25% by 2050 [40]. Without reducing physical inactivity in this group, it could impose a significant economic burden on public finances. Therefore, it is essential to create strategies to increase PA levels among the older adult population and, on the other hand, to maintain PA levels in middle-aged adults.

Lower educational levels were significant predictors in the trajectory of PA in the present study. Those who reported having no educational level exhibited an exponential increase in the odds of remaining inactive, making them the primary risk group in the study. These findings demonstrate the lack of opportunities, incentives, and information this group may have regarding PA in their routines. These data corroborate the literature, emphasizing the need for efforts to create programs that increase PA levels among socially disadvantaged groups in terms of education [14]. Consistent with these findings, researchers have shown that through Mendelian randomization, an additional year of education can increase PA by nearly half an hour more per week or 560 more steps per day in a Finnish sample [41]. Similarly, a study conducted in Italy, which tracked the trajectory of PA among adults of different socioeconomic positions, demonstrated a higher risk of physical inactivity among those with lower education levels (based on recreational PA) than those with higher education levels [42]. Furthermore, as in our study, individuals with lower levels of education exhibited a greater risk of worsening their PA during the follow-up period [42].

A study investigating the main barriers to PA among adults in Mexico found that obese individuals tend to report more barriers to engaging in PA [43]. Our findings indicated that being obese increased the odds of maintaining an inactive trajectory during the follow-up, as well as presenting higher odds of a decrease in PA during

this period. On the other hand, it also showed greater odds of increasing PA patterns or maintaining a weekend warrior pattern. When stratified by sex, the results remained significant only among women. Other studies that analyzed characteristics associated with lower PA trajectories also found similar results [36, 38, 44]. Obesity is a multifactorial condition, greatly influenced by lifestyle, primarily caused by an imbalance between caloric intake and expenditure [45]. Obese individuals often establish their habits early in childhood and adolescence, and generally exhibit low or no PA from a young age [45]. This habit persists throughout adulthood and becomes a difficult behavior to break over a lifetime [46]. Furthermore, the condition of obesity itself can create physical and psychological barriers that hinder an active lifestyle [45, 47].

Another predictor of PA trajectory identified was fruit and vegetable consumption. The results showed that a consumption of “<5x/week” increased the risk of a trajectory of physical inactivity and also of a decrease in PA. On the other hand, this same level of consumption was also a predictor for those who increased their PA patterns or maintained a weekend warrior pattern. It is important to emphasize that adequate consumption of fruit and vegetables, that is, “≥5x/week,” is considered a healthy dietary behavior, and often these behaviors are associated with other healthy habits, such as regular PA. As mentioned earlier regarding obesity behaviors, which often begin in childhood and persist into adulthood, fruit and vegetable consumption falls into this category. A study that followed PA trajectories and fruit and vegetable consumption for over 30 years, from childhood to midlife, concluded that those who were persistently active or increased their PA had higher fruit and vegetable consumption than those who were inactive or lightly active [48]. One behavior likely tends to influence the other throughout life, as both unhealthy and healthy behaviors tend to accumulate [49, 50]. Our findings reinforce the literature on the importance of healthy eating behaviors for a trajectory of greater PA throughout life, which may contribute to better future health, reducing the risk of physical and cognitive decline, as previously cited in studies analyzing this trajectory [49, 51].

The present study confirmed our initial hypotheses regarding many predictors of PA trajectory. On the other hand, the results also refuted our initial hypothesis that habits such as smoking would significantly predict a trajectory of physical inactivity, as observed in other studies [19, 36, 52]. Demographic characteristics may explain these conflicting results. Furthermore, smoking and engaging in PA may be incongruent behaviors [53]. Our study also expands the knowledge on the predictors of distinct PA trajectories throughout life, identifying at-risk groups more susceptible to a life of physical inactivity.

The findings also fill a gap in the literature with data from a country that is not part of the high-income country bloc [9].

A significant limitation of this study is the substantial sample loss (93.7%) from the original cohort, which resulted in biases in the representativeness of the final sample across various demographic and health characteristics, as demonstrated by a detailed sensitivity analysis. Therefore, caution is warranted when extrapolating the findings. The study also has important limitations related to the lack of detailed information on the volume and intensity of PA, particularly at baseline. More detailed data on amount and intensity were collected during the resurvey but not at the initial assessment; thus, we opted to analyze only the PA pattern based on comparable indicators available at both time points. Although the questions used to assess PA at baseline and resurvey captured the same key constructs (exercise/sports participation and frequency), the formats differed: baseline questions employed predefined categories, whereas the resurvey used open-ended numeric responses. These differences may introduce some measurement variability, although their impact on classification into the three defined activity patterns is likely minimal. The PA data obtained through questionnaires are also subject to common biases associated with self-reported measures. The Mexico City Prospective Study assessed PA using three simple questions rather than more detailed questionnaires; however, these questions have been validated and demonstrate good reliability [11–13]. Furthermore, given the long interval between assessments, we cannot determine how individuals' PA trajectories varied between the two time points. Finally, considering the many factors that can influence PA, this study included a limited number of potential predictors. Future research should aim to incorporate a broader range of explanatory variables. Additionally, stratified analyses by factors such as socioeconomic status, obesity, and age group could provide a more nuanced understanding of how different subgroups experience changes in PA patterns over time.

Despite its limitations, the study has strengths that should be highlighted, including its prospective design with an average follow-up of 16 years, which is extremely rare in Latin America. Additionally, it is noteworthy that this study was based on a large population-based sample of adults in Mexico.

Conclusion

Sex, age, education level, obesity, and fruit and vegetable consumption were factors associated with PA pattern trajectories. The factors influencing these trajectories varied notably between men and women, with certain factors being more strongly associated with specific trajectories in one sex than the other. These sex-specific differences

underscore the importance of considering gender when designing interventions. Our findings may be useful to serve as guidance for the development of health promotion strategies and encouragement of PA, focusing on the identified at-risk groups. This approach will enable the creation of more targeted and effective interventions, contributing to the mitigation of physical inactivity.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

ERdV and GF had a role in conceptualization, formal analysis, writing the original draft and editing the drafts. LFMR, AM, MMN, DGDC had a role in reviewing and editing. All authors contributed to the study design, critically reviewed the manuscript, and approved the final version.

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Data availability

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>.

Declarations

Ethics approval and consent to participate

The study followed the Declaration of Helsinki guidelines for research on human beings and was approved by the scientific and ethics committees within the Mexican National Council of Science and Technology (approval number 0595 P-M), the Mexican Ministry of Health, and the Central Oxford Research Ethics Committee (C99.260). Participants gave informed consent before taking part in the study.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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