



Investigation of Physical Activity Levels in the Population of Switzerland: Association With Lifestyle and Sociodemographic Factors

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Objective: The aim of the present study was to investigate physical activity levels of the population of Switzerland and the association of lifestyle and sociodemographic factors with physical activity levels.

Methods: The association of physical activity with lifestyle and sociodemographic factors was analyzed by fitting ordinal logistic regression models, using the data of 2057 participants from the National Nutrition Survey menuCH.

Results: The physical activity level of the population of Switzerland was high: less than 10% of the participants are not physically active. Factors associated with lower physical activity levels, were the sociodemographic variables, middle age [age 30–44: odds ratio = 0.53 (95% confidence interval 0.37, 0.77) and age 45–59: 0.60 (0.41, 0.89)] and higher education [tertiary level: 0.50 (0.29, 0.86)] as well as the lifestyle factors higher body mass index [obesity: 0.64 (0.45, 0.90)] and poor self-reported health status [0.68 (0.50, 0.93)].

Conclusion: To improve the physical activity level of the population of Switzerland tailored public health strategies are required that address specific groups, such as individuals in the middle age group or obese individuals.

Keywords: physical activity, healthy lifestyle factors, sociodemographic factors, menuCH study, ordinal logistic regression

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INTRODUCTION

Non-communicable diseases (NCD) rank prominently among the leading causes of global mortality, accounting for 71% of overall deaths [1]. The majority of all NCD deaths are caused by cardiovascular diseases (CVD, 44%), followed by cancer (22%), chronic respiratory diseases (9%), and diabetes (4%) [2]. For more than 10 years, CVD and cancer have been the first and second leading cause of death in Switzerland [3, 4].

NCD are caused by genetic, physiological, environmental, and behavioral factors, such as unhealthy diets, physical inactivity, smoking, and alcohol consumption [5–7]. Among these behavioral risk factors, physical inactivity is the fourth leading risk factor contributing to global mortality [8]. Previous studies have shown that risk factors for NCD often co-occur [9–11]. Physical activity (PA) has been linked to decreased

smoking [12] and healthier eating [13, 14] but is associated with higher alcohol consumption [15–17]. Adopting a holistic healthy lifestyle such as refraining from smoking, engaging in moderate to no alcohol consumption, following a healthy diet, and maintaining a healthy body weight is therefore crucial to prevent NCD.

Engaging in PA has not only protective effects on several NCD, for example on preventing obesity and cardiovascular diseases [18]. Several guidelines, including those of the World Health Organization (WHO), recommend meeting the goal of 150 min of moderate to vigorous PA per week [19, 20]. However, there is no linear relationship of health benefits and PA [21]. An umbrella review revealed that the most health benefits are achieved when going from an inactive state into an active state, irrespective of the amount of PA per week [22].

Around the early 2000s, over 30% of the world's population did not meet the WHO recommendations on PA [23]. In Switzerland, an increase in physically active people has been observed in the last 50 years, with 30% of the population of Switzerland being physically inactive in 1978 to only 18% in 2020 [24]. The number of people in Switzerland being physically active several times per week increased from 22% in 1978 to 57% in 2020 [24]. In 2022, a decrease in physical inactivity has been observed in Switzerland compared to 2020 mainly attributable to the restrictions (home-office, wearing of masks during indoor sport etc.) during the Coronavirus Disease 2019 pandemic [24].

Differences in PA levels were observed worldwide in different demographic and sociodemographic groups e.g., females compared to males, older adults compared to younger, and people of low sociodemographic status compared to those of high sociodemographic status [25]. Especially high-income compared to low-income countries have lower PA levels, which can mainly be explained by the motorized transportation [26].

It is crucial to understand the sociodemographic factors that impact an individual's commitment to maintain a physically active lifestyle and thereby reducing their risk for NCD. Healthy lifestyle factors in combination with sociodemographic factors have been investigated to understand the pattern of PA [26, 27]. To the best of our knowledge, further factors such as the information on dietary intake, self-reported general health status, or if the individuals follow a weight-loss diet, were only assessed in studies from the UK [28] and the US [29] but none from Switzerland [30, 31]. To fill this gap in knowledge, our study used population-based, representative Swiss data to investigate the association of PA with healthy lifestyle and sociodemographic factors.

METHODS

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were followed for the current study [32].

Study Design and Participants of menuCH Survey

Between January 2014 and February 2015, the cross-sectional Swiss National Nutrition Survey, menuCH, was conducted in ten

centers across Switzerland [30, 31]. Two 24-h dietary recalls (24HDR) were conducted, along with one self-administered questionnaire that included sociodemographic, dietary, and lifestyle variables as well as details about PA [31]. The target sample of the menuCH study covered the seven major regions of Switzerland (Lake Geneva, Midlands, Northwest, Zurich, Eastern, Central, and Southern Switzerland), the three main language regions (CH-German, CH-French, CH-Italian), five age categories (18–29, 30–39, 40–49, 50–64, and 65–75 years old), and both sexes (male, female) and consisted of 4,627,878 residents. From the source study sample of 13,606 individuals 5,496 eligible residents were successfully contacted by mail and phone. A total of 2086 individuals agreed to schedule an interview. Among them, 2057 completed two 24HDR, while the remaining 29 completed only one. The 2057 individuals with two complete 24HDR were included in the current study [33].

Physical Activity Assessment in menuCH

Data on PA was collected using the short-form International Physical Activity Questionnaire (IPAQ). The IPAQ was developed by an International Consensus Group in the late 1990s. It is a standardized tool to measure PA levels through a self-reported questionnaire with 7 questions to measure the amount and intensity of PA as well as the sitting time over the last 7 days. The IPAQ assesses PA during leisure, occupational, domestic, and commuting time, but does not distinguish between the different domains. PA is measured using the Metabolic Equivalent of Task (MET), which is a unit to measure the amount of energy expenditure of PA (walking = 3.3 METs, moderate PA = 4.0 METs, vigorous PA = 8.0 METs) [34, 35]. In our study, the participants were classified into three levels (high, moderate, and low). Participants in the high and moderate levels meet the recommended level of PA according to WHO [20]. The category high included participants who met any of the following criteria: vigorous-intensity activity on at least 3 days achieving a minimum of at least 1500 MET-minutes/week or 7 or more days of a combination of walking, moderate-intensity, or vigorous-intensity activities reaching a minimum of at least 3000 MET-minutes/week. The category moderate included participants meeting any of the following criteria: 3 or more days with at least 20 min of vigorous-intensity activity, 5 or more days of moderate-intensity or walking of at least 30 min per day, 5 or more days of any combination of walking, moderate-intensity, or vigorous-intensity activities accumulating a minimum of at least 600 MET-minutes/week. The category low included participant who did not meet the criteria for moderate or high PA levels [34].

Lifestyle and Sociodemographic Factors

The menuCH study included data on the participants' lifestyle and sociodemographic factors, which were collected with a self-administered questionnaire [33]. The following lifestyle factors were included in our study: Body mass index (BMI); calculated using the participants' body weight and height and classified according to WHO definitions: underweight (BMI <18.5 kg/m²), normal weight (18.5 kg/m² ≤ BMI <25.0 kg/m²), overweight

($25.0 \text{ kg/m}^2 \leq \text{BMI} < 30.0 \text{ kg/m}^2$), obese ($\text{BMI} \geq 30 \text{ kg/m}^2$), smoking habits (never, former, current), currently following a weight-loss diet (yes, no), and self-reported health status (good, medium-bad). The following sociodemographic variables were used in our study: sex (male, female), age group (divided in 4 categories: 18–29, 30–44, 45–59, and 60–75 years old), Swiss language region (CH-German, CH-French, CH-Italian), education level (primary, secondary, tertiary), and civil status (married, divorced, single, other).

Dietary Assessment in menuCH

Two 24HDR interviews were performed. The first interview was conducted face-to-face and 2 weeks later the second interview was conducted, which was done over the phone. Both interviews were performed by trained dietitians [36]. The food items reported in the interview were grouped in 19 categories using the trilingual Swiss version (0.2014.02.27) of the automated software GloboDiet® (GD, formerly EPIC-Soft®, IARC; Lyon, France [37, 38], adapted by the Federal Food Safety and Veterinary Office, Berne, Switzerland). The quantification of the consumed amounts was done with a book including 119 series of six graduated portion-size pictures and 60 actual household measures, which were presented to the participants [39].

The menuCH participants were categorized into three alcohol consumption categories (none, moderate, heavy) based on recommended intake thresholds given by the Swiss Federal Office of Public Health [40]. A male participant was classified as a heavy drinker if his daily alcohol consumption exceeded 24 g of pure alcohol, and a female participant was classified as a heavy drinker if her daily alcohol consumption exceeded 12 g of pure alcohol. A male participant consuming 24 g or less of pure alcohol per day and a female participant consuming 12 g or less of pure alcohol per day were classified as moderate drinkers [41]. Non-alcohol-consumer were those participants who declared in the self-administered questionnaire to avoid drinking alcohol and did not report any alcohol consumption during either 24HDR.

The Alternative Healthy Eating Index (AHEI) score was calculated based on ten components (0–10 points per component), namely vegetables, fruits, whole grains, sugar sweetened beverages, nuts, meat, trans fat, long chain omega-3 fatty acids, polyunsaturated fatty acids, sodium, and alcohol. Higher AHEI scores indicate a higher diet quality [42]. The AHEI score is calculated for each 24HDR and the average of both AHEI scores was determined. The alcohol component was excluded from the AHEI score used in our analysis, as alcohol was considered as a separate exposure variable.

Statistical Analysis

The menuCH study sample was weighted based on sex, age, marital status, major living region, nationality, household size, weekday and season of the 24HDR day to ensure having a representative sample of the population of Switzerland. The weighting strategy is described in detail in the open survey data repository [43].

Descriptive statistics [absolute numbers, percentages, median, and interquartile range (IQR)] were used to characterize the study population.

Multivariate imputation by chained equations (MICE) was used to impute missing values for PA level ($n = 524$), education level ($n = 3$), sitting time ($n = 585$), currently being on a diet ($n = 4$), self-reported health status ($n = 4$), civil status ($n = 3$), and smoking category ($n = 4$) [44]. Rubin's rule was used to pool the results of the 25 imputed data sets [45].

Ordinal regression models were fitted to investigate the association between PA level and sociodemographic and lifestyle factors. The dependent variable, PA level, was defined as an ordinal outcome because it has a natural order (low < moderate < high). Therefore, an ordinal logistic regression approach was chosen, adjusted for sex, age group, Swiss-language region, education level, civil status, nationality, smoking, alcohol intake, BMI, health status, and currently on a diet. All confounders were chosen a priori.

Separate models were fitted for males and females to explore potential sex-based differences in the associations between PA levels and the sociodemographic and lifestyle factors.

To assess the goodness-of-fit of the model, the Hosmer-Lemeshow test and the Pulkstenis-Robinson test were conducted with each 25 imputed data sets. Subsequently, the median estimates were determined. The Hosmer-Lemeshow test groups the observations based on deciles of predicted probabilities for the outcome variables and compares the observed and expected frequencies within each group using a Chi-squared statistic. The Pulkstenis-Robinson test groups observations into homogenous groups based on predicted probabilities for the outcome variables and compares observed and expected frequencies within each group. Chi-squared test and deviations tests are used to provide p-values to assess model fit [46].

For the sensitivity analysis, the original ordinal regression model was additionally adjusted for income and/or sitting time as explanatory variables. The first model included income as additional explanatory variable, the second model sitting time, and the third model both, income and sitting time, to explore the effect on PA levels.

The R programming language (version 4.1.2) was used to conduct all analyses. The following R packages were used for weighting (stats), ordinal logistic regression (MASS), multivariate imputation by chained equations (mice) and goodness-of-fit tests (generalhoslem) [47]. The statistical significance level was set to 0.05 for all analyses.

RESULTS

Descriptive Results

Baseline characteristics of the menuCH participants stratified by PA level are shown in **Table 1**. The largest group was the high PA group with 827 (40.2%) individuals, followed by the moderate PA group with 487 (23.7%) individuals, and the smallest group was the low PA group with 219 (10.7%) individuals. 524 (25.5%) individuals did not provide complete information on PA and therefore the PA level could not be determined. 63.9% of all participants (participants with a moderate and high PA level) met the PA recommendations, which is a minimum of 150 min of

TABLE 1 | Baseline characteristics of menuCH participants (n = 2057) stratified by physical activity group^a (National Nutrition Survey menuCH, Switzerland, 2014–2015).

Variable	Overall	Low	Moderate	High	NA
n	2057	219	487	827	524
Female, n (% , %*)	1,124 (54.6, 50.2)	96 (43.8, 39.6)	280 (57.5, 54.2)	422 (51.0, 48.2)	326 (62.2, 54.4)
Age (IQR)	47 (33, 59)	46 (37, 54)	45 (32, 59)	48 (32, 60)	46 (33, 59)
Age group, n (% , %*)					
18–29	400 (19.4, 18.8)	26 (11.9, 8.2)	89 (18.3, 15.5)	176 (21.3, 22.5)	109 (20.8, 20.8)
30–44	533 (25.9, 29.9)	71 (32.4, 40.1)	141 (29.0, 34.4)	183 (22.1, 25.3)	138 (26.3, 28.5)
45–59	625 (30.4, 29.6)	87 (39.7, 38.4)	138 (28.3, 28.5)	250 (30.2, 28.1)	150 (28.6, 29.3)
60–76	499 (24.3, 21.6)	35 (16.0, 13.4)	119 (24.4, 21.7)	218 (26.4, 24.1)	127 (24.2, 21.4)
Language region, n (% , %*) ^b					
German	1,341 (65.2, 68.8)	156 (71.2, 72.3)	309 (63.4, 69.0)	542 (65.5, 68.9)	334 (63.7, 66.8)
French	502 (24.4, 25.7)	36 (16.4, 20.8)	125 (25.7, 25.0)	209 (25.3, 26.1)	132 (25.2, 27.8)
Italian	214 (10.4, 5.6)	27 (12.3, 6.9)	53 (10.9, 6.0)	76 (9.2, 5.0)	58 (11.1, 5.4)
Education level, n (% , %*)					
Primary	89 (4.3, 4.6)	6 (2.7, 2.8)	16 (3.3, 3.0)	38 (4.6, 5.5)	29 (5.5, 5.7)
Secondary	968 (47.1, 43.1)	96 (43.8, 41.1)	205 (42.1, 36.2)	388 (46.9, 43.3)	279 (53.2, 50.4)
Tertiary	997 (48.5, 52.0)	117 (53.4, 56.2)	266 (54.6, 60.9)	401 (48.5, 51.2)	213 (40.6, 42.8)
NA	3 (0.1, 0.3)	0 (0.0, 0.0)	0 (0.0, 0.0)	0 (0.0, 0.0)	3 (0.6, 1.1)
Nationality, n (% , %*)					
Swiss	1,492 (72.5, 60.6)	152 (69.4, 52.2)	351 (72.1, 61.1)	609 (73.6, 62.2)	380 (72.5, 61.4)
Non-Swiss	268 (13.0, 25.0)	41 (18.7, 35.8)	64 (13.1, 25.1)	99 (12.0, 22.7)	64 (12.2, 23.7)
Swiss binationals	297 (14.4, 14.3)	26 (11.9, 11.9)	72 (14.8, 13.8)	119 (14.4, 15.1)	80 (15.3, 14.8)
Civil status, n (% , %*)					
Single	634 (30.8, 30.9)	63 (28.8, 28.6)	155 (31.8, 29.9)	257 (31.1, 32.9)	159 (30.3, 29.6)
Married	1,125 (54.7, 52.5)	124 (56.6, 56.2)	269 (55.2, 55.9)	451 (54.5, 50.5)	281 (53.6, 50.9)
Divorced	223 (10.8, 11.7)	25 (11.4, 11.1)	44 (9.0, 9.2)	92 (11.1, 12.1)	62 (11.8, 13.9)
Other	72 (3.5, 4.6)	7 (3.2, 4.1)	19 (3.9, 5.0)	27 (3.3, 4.4)	19 (3.6, 4.6)
NA	3 (0.1, 0.3)	0 (0.0, 0.0)	0 (0.0, 0.0)	0 (0.0, 0.0)	3 (0.6, 1.1)
BMI (IQR)	24.3 (21.8, 27.2)	25.4 (22.7, 28.7)	24.0 (21.4, 27.4)	24.1 (21.8, 26.8)	24.3 (21.8, 27.5)
BMI group, n (% , %*)					
Underweight	51 (2.5, 2.3)	2 (0.9, 0.3)	11 (2.3, 2.4)	19 (2.3, 2.0)	19 (3.6, 3.7)
Normal	1,115 (54.2, 54.4)	100 (45.7, 47.5)	266 (54.6, 54.0)	474 (57.3, 58.9)	275 (52.5, 50.6)
Overweight	629 (30.6, 30.7)	74 (33.8, 33.2)	151 (31.0, 32.2)	255 (30.8, 29.4)	149 (28.4, 30.3)
Obese	262 (12.7, 12.5)	43 (19.6, 19.0)	59 (12.1, 11.4)	79 (9.6, 9.7)	81 (15.5, 15.4)
Currently on a diet, n (% , %*)					
No	1940 (94.3, 93.9)	207 (94.5, 94.9)	453 (93.0, 92.8)	789 (95.4, 95.7)	491 (93.7, 91.8)
Yes	113 (5.5, 5.7)	12 (5.5, 5.1)	34 (7.0, 7.2)	38 (4.6, 4.3)	29 (5.5, 7.0)
NA	4 (0.2, 0.3)	0 (0.0, 0.0)	0 (0.0, 0.0)	0 (0.0, 0.0)	4 (0.8, 1.3)
Health status, n (% , %*)					
Good	1781 (86.6, 93.9)	182 (83.1, 94.9)	420 (86.2, 92.8)	743 (89.8, 95.7)	436 (83.2, 91.8)
Medium-bad	272 (13.2, 5.7)	37 (16.9, 5.1)	67 (13.8, 7.2)	84 (10.2, 4.3)	84 (16.0, 7.0)
NA	4 (0.2, 0.3)	0 (0.0, 0.0)	0 (0.0, 0.0)	0 (0.0, 0.0)	4 (0.8, 1.3)
Alcohol intake, n (% , %*)					
None	870 (42.3, 41.0)	99 (45.2, 47.1)	188 (38.6, 35.5)	356 (43.0, 41.0)	227 (43.3, 43.4)
Moderate	613 (29.8, 29.3)	63 (28.8, 28.5)	154 (31.6, 32.2)	253 (20.6, 29.8)	143 (27.3, 26.0)
Heavy	574 (27.9, 29.8)	57 (26.0, 24.4)	145 (29.8, 32.4)	218 (26.4, 29.2)	154 (29.4, 30.6)
Smoking, n (% , %*)					
Never	914 (44.4, 42.0)	98 (44.7, 43.2)	212 (43.5, 41.1)	380 (45.9, 42.2)	224 (42.7, 40.8)
Former	688 (33.4, 35.4)	80 (36.5, 38.6)	161 (33.1, 33.7)	271 (32.8, 35.4)	176 (33.6, 35.4)
Current	451 (21.9, 22.4)	41 (18.7, 18.8)	114 (23.4, 25.2)	176 (21.3, 28.4)	120 (22.9, 25.6)
NA	4 (0.2, 0.3)	0 (0.0, 0.0)	0 (0.0, 0.0)	0 (0.0, 0.0)	4 (0.8, 1.3)
AHEI (IQR) ^c	40.1 (31.9, 48.4)	37.0 (29.8, 46.5)	41.9 (33.0, 49.6)	40.3 (32.0, 49.1)	38.9 (30.8, 47.2)
Sitting time, h (IQR)	6.0 (4.0, 9.0)	8.0 (5.0, 10.8)	7.0 (4.5, 10.0)	5.0 (3.5, 8.0)	NA

BMI, body mass index; IQR, interquartile range; AHEI, alternative healthy eating index; NA, missing; h, hours.

^aCategorical variables are represented as absolute number (n), unweighted percentage (%), and weighted percentage (%*). Continuous variables are expressed as weighted median and interquartile range (IQR). The weighted percentages (%*), weighted median, and weighted IQR are weighted according to the menuCH weighting strategy [43]. The weighting strategy included sex, age, marital status, major living region Switzerland, nationality, household size, weekday and season of the recall day [43].

^bGerman language region: cantons Aargau, Basel City, Basel Country, Berne, Lucerne, Zurich, and St. Gallen. French language region: cantons Jura, Neuchâtel, Vaud, and Geneva. Italian language region: canton Ticino.

^cThe AHEI is calculated as average AHEI of the two 24-h dietary recall. It comprises of ten components, which contribute each 0 to 10 points: vegetables, fruits, whole grains, sugar sweetened beverages, nuts, meat, trans fat, long chain omega-3 fatty acids, polyunsaturated fatty acids (PUFA), and sodium. The higher the AHEI score, the healthier the participant's diet. Alcohol is not included in the AHEI score of the current study, because it is investigated as a separate value [42].

TABLE 2 | Results of the ordinal logistic regression model for sociodemographic and lifestyle factors associated with physical activity level (n = 2057). (National Nutrition Survey menuCH, Switzerland, 2014–2015).

	OR ^a	[95% CI]
Sex		
Male (ref.)	1.00	-
Female	0.93	[0.76, 1.15]
BMI		
Normal (ref.)	1.00	-
Underweight	1.18	[0.60, 2.36]
Overweight	0.84	[0.67, 1.05]
Obese	0.64	[0.45, 0.90]*
Age		
18–29 (ref.)	1.00	-
30–44	0.53	[0.37, 0.77]*
45–59	0.60	[0.41, 0.89]*
60–76	0.88	[0.56, 1.31]
Language region		
German (ref.)	1.00	-
French	1.11	[0.87, 1.42]
Italian	0.85	[0.61, 1.29]
Nationality		
Swiss (ref.)	1.00	-
Non-Swiss	0.81	[0.61, 1.09]
Swiss binationals	0.99	[0.74, 1.33]
Education		
Primary (ref.)	1.00	-
Secondary	0.58	[0.33, 1.02]
Tertiary	0.50	[0.29, 0.86]*
Health status		
Good (ref.)	1.00	-
Medium-bad	0.68	[0.50, 0.93]*
Smoking		
Never (ref.)	1.00	-
Former	1.00	[0.80, 1.26]
Current	1.01	[0.78, 1.33]
Civil status		
Single (ref.)	1.00	-
Married	1.05	[0.81, 1.36]
Divorced	1.25	[0.86, 1.83]
Other	0.89	[0.56, 1.38]
Currently on a diet		
No (ref.)	1.00	-
Yes	0.89	[0.56, 1.38]
Alcohol intake		
None (ref.)	1.00	-
Moderate	0.97	[0.76, 1.25]
Heavy	1.00	[0.78, 1.29]
AHEI score	1.00	[0.99, 1.01]

*p < .05.

BMI, body mass index; AHEI, alternative healthy eating index; OR, odds ratio; CI, confidence interval.

^aThe OR are weighted according to the menuCH weighting strategy for sex, age, marital status, major living region Switzerland, nationality, household size, weekday and season of the recall day [43].

moderate PA. Participants aged 30 to 59 were more likely to be in the low PA group, compared to the younger (aged 18–29) and older (aged 60–76) participants. German- and French-speaking participants were more likely to be in the low PA group compared to the Italian-speaking participants, as well as obese and overweight participants compared to the underweight and normal weight participants. No trend in alcohol intake, AHEI score, smoking status, civil status, or nationality among the PA

levels was observed. Individuals with a low PA level had higher median daily sitting time (8 h) than individuals in the moderate (7 h) and high (5 h) PA group.

Ordinal Logistic Regression

The association between PA and several sociodemographic and lifestyle factors based on an ordinal logistic regression model are shown in **Table 2**. The findings suggested an influence of the sociodemographic factors, as well as indicating an association with the lifestyle factors BMI and self-reported health status and PA level. Sociodemographic variables, such as age and education level emerged as notable correlates of PA level. Specifically, individuals aged 30–44 and 45–59 in comparison to those aged 18–29 had lower odds [OR = 0.53, 95% CI (0.37, 0.77) and 0.60 (0.41, 0.89)] of being in a higher PA level (compared to the lower PA levels). Similarly, individuals with tertiary education in comparison to individuals with a primary education had lower odds [0.50 (0.29, 0.86)] of being in a higher PA level (compared to the lower PA levels).

The other sociodemographic factors, namely sex, language region, nationality, and civil status, did not reveal evidence for an association with PA levels.

The two lifestyle factors that were significantly associated with PA levels, were BMI and self-reported health status. Obese individuals in comparison with normal weight individuals had lower odds [0.64 (0.45, 0.90)] of being in a higher PA level (compared to lower PA levels). Individuals reporting a medium to bad health status had lower odds [0.68 (0.50, 0.93)] of being in a higher PA level (compared to the lower PA levels) compared to individuals reporting a good health status. For the other lifestyle factors (smoking status, being on a diet, alcohol consumption, and AHEI score), no association with PA levels was observed.

To explore the sex-based differences in the association between PA and sociodemographic and lifestyle factors, the analysis was stratified by sex. The findings suggest that there is a difference between males and females. In the model including only females, we did not observe any statistically significant associations between sociodemographic and lifestyle factors and PA level (**Supplementary Table SI 1**). In the male-only model, the following associations are consistent with those in the main model: age 30–44 [0.38 (0.11, 0.69)] and 45–59 [0.43 (0.23, 0.79)] years, education [tertiary 0.45 (0.42, 0.95)], and self-reported health status [bad to medium 0.63 (0.42, 0.95)]. In contrast, BMI was no longer significantly associated with PA, but secondary education was associated [0.46 (0.21, 0.99)] (**Supplementary Table SI 1**).

Goodness-Of-Fit

The Hosmer-Lemeshow and the Pulkstenis-Robinsons tests were performed to assess the goodness-of-fit of the ordinal logistic regression model. The Hosmer-Lemeshow test produced a Chi-squared statistic of 15.285 (df = 7, p = 0.033), indicating a potential lack of fit. The Pulkstenis-Robinson test yielded a median Chi-squared test statistic of 3,598.6 (df = 3,528, p = 0.200) and the deviance test resulted in a median value of 3,485.8 (df = 3,528, p = 0.690). Both, the Chi-squared test and the deviance test, indicated no significant lack of fit.

Sensitivity Analysis

We conducted a sensitivity analysis exploring the variables income and sitting time as additional explanatory variables in the regression analysis on the association of sociodemographic and lifestyle factors with PA levels (**Supplementary Table SI 2–4**). The regression model additionally adjusted for income (**Supplementary Table SI 2**) indicated that income was not statistically significantly associated with PA. The regression model additionally adjusted for sitting time (**Supplementary Table SI 3**) revealed that sitting time was negatively associated with PA level, while education was no longer significantly associated with PA level. Including both, income and sitting time, as additional explanatory variables in the regression model (**Supplementary Table SI 4**) confirmed that sitting time remained negatively associated with PA level, while income still was not.

DISCUSSION

The population of Switzerland was in general physically active with the majority of the participants belonging to the moderate and high PA level. PA levels were associated with the sociodemographic factors age group and education level. Among the lifestyle factors, we observed an association of BMI group and self-reported general health status with PA level. By performing the analysis stratified by sex, we could detect a difference among the sexes. The results for the males are similar to the main results, while the analysis for the females revealed no statistically significant associations. In the sensitivity analysis, increased sitting time was significantly associated with lower odds of having a high PA level, while education was not significantly associated anymore. The findings of our study might help to tailor future preventive strategies against NCD in Switzerland.

Our study showed that the PA level of the population of Switzerland was high; only 10% (individuals with low PA level) did not meet the minimum criteria of PA as defined by WHO [8]. Our results are consistent with the findings of the Swiss Health Survey in 2017, reporting that three out of four individuals were sufficiently physically active and only 9% were inactive [48]. According to Sport Switzerland and a study from Geneva, the levels of PA increased over the last years [49, 50]. In 2020, only 15% of the Swiss individuals were inactive, whereas over 30% were inactive in 1978 [50].

The combination of the Pulkstenis-Robinson and Hosmer-Lemeshow test suggested that the model fits the data reasonably well.

In our study, no evidence for an association of PA levels with sex was observed. Therefore, disparities in access to PA opportunities [51] and gender inequality, such as social expectations [52], leading to a lower PA level among females compared to males [23, 51–53], do not seem to be generally evident in Switzerland.

Compared to the reference age group (18–29), the two middle age groups (30–59) showed evidence for having lower odds of being in a higher PA level, whereas the oldest age group (60–76) did not. A potential explanation for the absence of an association could be the

small sample size in the oldest and youngest age group compared to the two middle age groups, leading to wider confidence intervals. Additionally, the oldest age group probably included mostly retired participants, which have more free time they might have spent on physical activities, leading therefore to a statistically insignificant trend of lower odds to be in a higher PA level compared to the youngest age group. Meanwhile, in another Swiss study with participants over 52 years of age, it was observed that the PA level decreased with age [54]. We also found that individuals with a tertiary education were less physically active compared to individuals with a lower education. This contrasts with previous studies which indicate that various domains of PA – such as occupational PA, leisure-time PA, and transportational PA – exhibit distinct associations with educational status. Specifically, individuals with tertiary education tend to have higher levels of leisure-time PA, while those with lower education engage more in occupational PA [55–57]. This disparity highlights the importance of considering the specific domains in PA in future research to better understand and address inequalities in PA levels across different education levels.

In our study, individuals being obese and reporting medium to bad health status had lower odds of being in a higher PA level compared to the “respective” “reference” group, meanwhile the other lifestyle factors were not associated with PA levels. Previous studies have observed an association of high PA with normal BMI and a good general health status, whereas other studies also observed an association with non-smoking behavior [58–60]. The association between smoking and PA depends on the type of PA. Occupational or commuting PA are risk factors for smoking and leisure-time PA is associated with a lower smoking behavior [12]. PA also influences eating behavior, it has been shown that individuals engaging in regular PA tend to have a healthier diet [13, 14], however they tend to consume more alcohol [15–17]. We did not observe these associations in our analysis, potentially due to the small sample size and the cross-sectional study design, capturing data only at a single point in time. Additionally, factors such as smoking behavior were categorized relatively broadly (i.e. former, never, current), which could have limited the sensitivity of our analysis to detect associations.

To observe potential sex-based differences, we stratified our study population by sex. Statistically significant associations between PA levels and sociodemographic and lifestyle factors were observed for the male subgroup, whereas for the female subgroup similar trends were observed, which, however, were not statistically significant. Nonetheless, we suggest that the observed associations in the whole population and the male subgroup should also be considered when planning female-specific PA strategies. Further sex-specific studies with larger sample sizes are needed to assure our observed trends, especially among the female subgroup, are indeed significant associations with PA levels and therefore an effective target for future PA strategies.

As individuals with a tertiary education spend more time sitting, we conducted a sensitivity analysis and included sitting time in the model, which revealed that education was no longer statistically significantly associated with PA, while sitting time was. The latter findings suggest that the lower levels of PA of

individuals with tertiary education were due to increased sitting time associated with education level rather than the education level *per se*. This finding highlighted the importance of including the sedentary behavior into analyses of PA behaviors. Research findings indicated that the relative risk for CVD linked to sedentary behavior is more pronounced among individuals with low levels of PA [61, 62]. Moreover, a sedentary behavior is a risk factor for CVD, independent of the PA level [63]. Notably, engaging in a high level of PA appears to mitigate the adverse consequences of sedentary behavior on cardiovascular health [64].

Our results should be considered with some limitation. In menuCH, PA and other variables (e.g. income, education level, health status, and smoking behavior) were collected via self-reporting, which can result in recall, information, and misclassification bias. PA was measured using the short IPAQ questionnaire, which does not distinguish between the different domains of PA, especially between leisure and occupation PA. PA data is missing for almost 25% of the participants, potentially introducing selection bias, as the characteristics of the individuals with missing PA may differ systematically from those who provided complete data. Lastly, menuCH is a cross-sectional study and therefore, no cause-effect conclusions can be drawn.

However, our study had important strengths. The menuCH study population is representative for the population of Switzerland due to the survey weighting strategy. Other strengths are the dietary assessment tool and the IPAQ. Two 24HDR were conducted and analyzed using the GloboDiet[®] [38] by trained dietitians [36]. The IPAQ is an international and validated standard tool to measure PA. The last strength is the available data on sitting time, which could be included in the sensitivity analysis.

Conclusion

The majority of the population of Switzerland met the WHO recommendations on PA. Sociodemographic and lifestyle factors, such as education level, age group, BMI group, and self-reported health status are related to an individual's PA level. We observed that sedentary behavior is an important risk factor for lower PA levels. This is particularly concerning given the increasing sitting time observed in the population of Switzerland. Additionally, our findings highlight differences between males and females. Future studies should focus on sedentary behavior, with a clear distinction between occupational and leisure-time PA, as well as more detailed analysis to investigate the difference between sexes. The findings of our study might shape decisions of policymaker and thereby help to plan future preventive strategies against NCD.

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DATA AVAILABILITY STATEMENT

The data and further documents of the menuCH study are available by request under <https://menuch.iumsp.ch>.

ETHICS STATEMENT

The menuCH survey followed the ethical principles of the Declaration of Helsinki. All procedures were approved by the lead ethics committee in Lausanne (protocol 26/13) and the corresponding cantonal ethics committees. The survey is registered and has the international standard randomized controlled trial number (ISRCTN) 16778734. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

FB: conceptualization, methodology, data curation, formal analysis, writing—original draft, visualization. FS: conceptualization, methodology, formal analysis, writing—review and editing. SR: conceptualization, methodology, resources, supervision, writing—review and editing. All authors contributed to the article and approved the submitted version.

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CONFLICT OF INTEREST

The authors declare that they do not have any conflicts of interest.

GENERATIVE AI STATEMENT

The author(s) declare that no Generative AI was used in the creation of this manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.ssph-journal.org/articles/10.3389/ijph.2025.1608010/full#supplementary-material>

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