Applied nutritional investigation

Clustering of sociodemographic and lifestyle factors among adults with excess weight in a multilingual country

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ABSTRACT

Objective: The aim of this study was to identify and cluster potential sociodemographic and lifestyle determinants of excess weight (body mass index $\geq$ 25 kg/m^2) in Switzerland.
Methods: Participants of the cross-sectional National Nutrition Survey menuCH (2014−2015, n = 2057) were categorized according to body mass index. Logistic regressions were conducted with sociodemographic (age, language region, education, household income, household status) and lifestyle factors (smoking, self-rated health status, physical activity, energy intake, Alternate Healthy Eating Index) to identify determinants of excess weight. Factorial analysis and clustering were applied to identify patterns among individuals with excess weight (n = 891).
Results: Poor or very poor self-rated health status and low levels of physical activity were associated with increased odds for obesity in men (odds ratio [OR] = 5.39 [95% confidence interval = 5.30−5.48], OR = 2.51 [2.14−2.95], respectively) and women (OR = 12.40 [11.59-13.26], OR = 4.83 [3.04−7.67], respectively). In both sexes, the Alternate Healthy Eating Index score was inversely associated with the probability of having obesity. Cluster analysis identified four distinct patterns: "young living with parents" (14.6%), "men with high educational level" (41.5%), "women living alone" (34.9%), and "low educational level and Italian language region" (9.0%).
Conclusions: We identified four discrete subgroups of individuals with excess weight who differed by sociodemographic and lifestyle factors. Such subgroups may prove useful for targeted public health interventions.
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Introduction

Overweight and obesity have become increasingly important health concerns worldwide [1]. In 2016 the prevalence of overweight (body mass index $25 \leq$ BMI < 30 kg/m^2) for people with age 18 y or older was 39% and 13%, respectively [2]. Overweight and obesity (hereafter "excess weight") have multifactorial causes [3]. Recently it has been found that it is important to extend the concept of lifestyle as determinant of excess weight and include social, economic, and environmental cofactors of lifestyle [4].

In Switzerland the prevalence of obesity is among the lowest in Europe [5]. However, studies have found that excess weight is unequally distributed among the Swiss population depending on socioeconomic background (education level, occupation, income) and cultural or geographic origin [6,7]. In fact, Switzerland consists of three main language regions—German, French, and Italian—with distinct sociocultural differences and respective cultural peculiarities partially also prevailing in the neighboring countries Germany, France, and Italy. Furthermore, lifestyle factors such as dietary habits, physical activity levels, alcohol consumption, and tobacco use have been found to be associated with excess weight in various studies conducted in the general population [8–10]. These studies, however, were based on the Swiss Health Survey (SHS) [8], which comprises only crude and self-reported dietary, physical activity, and anthropometric data.

To date, no detailed and reliable information on the association between measured anthropometric adiposity parameters and lifestyle

has been available in Switzerland. To fill this gap, we first aimed to investigate how individuals with excess weight differed from participants with normal weight regarding sociodemographic and lifestyle factors, using the newly available data of the National Nutrition Survey menuCH. MenuCH is the first national and representative study carried out in Switzerland comprehensively evaluating the diet of the population through two 24-h dietary recalls (24HDRs) and providing additional sociodemographic and measured anthropometric covariables [11].

Individuals with excess weight, however, may represent a heterogeneous group, requiring different prevention approaches. To our knowledge, no studies have investigated the heterogeneity of individuals with excess weight, thus our second aim was to identify discrete subgroups of individuals with excess weight that differ by sociodemographic and lifestyle factors. Given the absence of methods consensus, we used a data-driven approach.

Methods

Study design

The cross-sectional nutrition survey menuCH was conducted in 2014 to 2015 by the Institute of Social and Preventive Medicine of the University of Lausanne (IUMSP) and the Swiss Federal Food Safety and Veterinary Office [11]. It includes the three main language regions of Switzerland [11]. Written informed consent was obtained from each participant [11]. The study was carried out in accordance with ethical standards defined in the Declaration of Helsinki (the main study was approved by the regional ethics lead committee in Lausanne, Protocol 26/13) [11]. Time investment and travel costs were compensated [11]. More details about study design and data collection were described elsewhere [11,12].

Population

Overall, the net response rate in menuCH was 38.0% [12]. Population-based data were collected from 2086 participants ages 18 to 75 y, representing 4 627 878 residents domiciled in the most populated cantons of the seven administrative regions of Switzerland (Lake Geneva, Midlands, Northwest, Zurich, Eastern, Central, and Southern Switzerland) [11]. The final sample is representative of the three main language regions of Switzerland [11]. We included 2057 individuals (98.7%) who fully completed both 24HDRs in our analysis.

Anthropometric measurement

Anthropometrics were measured to the nearest 0.1 kg and 0.1 cm by trained staff according to official protocols [11]. We categorized measured BMI (kg/m^2) into subgroups of underweight (BMI < 18.5 kg/m^2), normal-weight (18.5 ≤ BMI < 25.0 kg/m^2), overweight (25.0 ≤ BMI < 30.0 kg/m^2), obesity (BMI ≥ 30.0 kg/m^2) [13], and excess weight (BMI ≥ 25 kg/m^2). For seven participants, only self-reported BMI was available (handicapped or refused to be measured). For 27 pregnant or lactating women, we calculated a composite BMI (self-reported weight before pregnancy and measured height). We defined these overall 34 individuals with (partially) reported height and weight as missing in the descriptive analysis (see Statistical Analyses).

Dietary assessment

Diet was assessed by two 24HDRs: In brief, the first face-to-face and the second phone 24HDR (2–6 wk later) were distributed across all weekdays and seasons. The 24HDRs were multiple-pass and automated using an adapted version of the GloboDiet software. The software displayed food group–specific descriptors, allowing for highly standardized description of foods and recipes, such as cooking and preservation methods and sugar and fat contents. To support survey participants in quantifying consumed amounts, a book with 119 series of six graduated portion size pictures and a set of about 60 actual household measures were used; for details see Chatelan et al. [12,14]. The Alternate Healthy Eating Index (AHEI), an indicator of the quality of the diet (the higher the score the healthier the diet; maximum score = 110), was calculated for both days of the 24HDR [15]. AHEI scores (and their subcomponents fruit, whole grains, sugar-sweetened beverages and fruit juices, red or processed meat, polyunsaturated fatty acids [PUFA], sodium, and alcohol) and energy intakes presented here are the mean of the two 24HDRs.

Assessment of sociodemographic and lifestyle factors

Participants completed a general questionnaire before their face-to-face 24HDR [11]. Physical activity was assessed with the short-form International Physical Activity Questionnaire (IPAQ-SF, the standard technique to assess physical activity levels [16]) and categorized into three levels (high, moderate, and low) following IPAQ classifications. For the other sociodemographic and lifestyle variables (sex, age, language region, nationality, educational level, marital status, household income, household status, occupation, smoking, and self-rated health status [SRH]), we used the categorization as previously defined [11]. Educational was categorized into three levels: primary (participants with no degree or with a compulsory school degree, International Standard Classification of Education, ISCED 1-2), secondary (completed high school or apprenticeship, ISCED 3-4), and tertiary (higher degree requesting a high school diploma, ISCED 5-6) [11]. Details about the assessment of covariables were described elsewhere [12].

Because physical activity and income had high proportions of missing values, we imputed the most common value for all variables introduced in the regression and cluster analysis based on multiple imputation by chained equations [17] (Table S1).

Statistical analyses

Population characteristics

We calculated descriptive statistics (relative frequencies, means, standard deviations, and the first and third quartiles) for sociodemographic and lifestyle subgroups (partially presented as supplementary material). Using the sample weights provided by the Institute of Social and Preventive Medicine of the University of Lausanne, the results were weighted for age group, sex, marital status, major region, nationality, and household status [12]. Variables derived from the 24HDRs were additionally adjusted for season and weekday.

Multinomial logistic regression

We performed multinomial logistic regressions to analyze differences regarding sociodemographic and lifestyle factors between people with normal weight and people with overweight, obesity, or excess weight. We calculated odds ratios (ORs) and 95% confidence intervals (CIs) in two mutually adjusted models: one differentiating between overweight and obesity (25.0 ≤ BMI < 30.0 kg/m^2 and BMI ≥ 30.0 kg/m^2) and one combining overweight and obesity (BMI ≥ 25.0 kg/m^2). People with normal weight were the reference group in both models; people with underweight were included in both models, but their results are not reported because of the small sample size (2.4%).

First, we included age and sex in the models, followed by the sociodemographic variables, then risk behaviors and SRH, and last physical activity and nutrition. We selected variables according to the Akaike information criterion, except for three standard variables (language region, smoking, and AHEI) that were included in the model regardless of Akaike information criterion. We considered Cramer's V measure of association to assess correlation between independent variables. To visualize the predicted probability to be in one of the BMI categories we produced effect plots based on the fully adjusted logistic regressions model differentiating between overweight and obesity.

Because there were several statistically significant interactions ($P < 0.05$) among sex and age, education, AHEI, and energy intake, we stratified our analysis by sex.

All regression results were weighted for age group, sex, marital status, major region, nationality, and household status. The weights applied in the regression analyses were transformed to fractional amounts (the sum of the sample weights was equal to the sample size).

Cluster analysis

To identify sociodemographic and lifestyle patterns among participants with excess weight, we applied a two-step procedure. First, we applied factor analysis of mixed data (FAMD), a principal component method [18], to all variables that were included in the regression models. Variables characterizing diet and BMI (components of AHEI and BMI ≥ 25 kg/m^2) were included as supplementary variables so that they did not influence the partition but could be used for dietary and BMI description of the clusters. A cumulative inertia greater than 50% (Fig. S1) was used as criterion to choose the number of principal components to retain. No clear breaks appeared in the scree plot, and it was therefore not considered as a criterion (Fig. S2). Second, we used the first eight principal components of the FAMD as inputs to Ward's hierarchical clustering [19]. The defined partition was further consolidated using a k-means algorithm.

Associations between the sociodemographic and lifestyle patterns and the defined clusters were investigated using a v test and analyzing if the distribution (for continuous variables) or the proportion of categories (for categorical variables) differed from all individuals with excess weight. The same procedure was applied to determine the association between the dietary and BMI variables and the sociodemographic and lifestyle patterns.

Software

All analyses were performed with R Version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria). The FactomineR package [20] was used to apply FAMD and clustering on our data. The regression analyses were performed using the nnet package [21], the probability plots were set up with the effects package [22], and the imputation was based on the mice package [17].

Results

Population characteristics

Sociodemographic and lifestyle characteristics of the study population are shown in Table 1. The overall prevalence of overweight and obesity was 30.7 % and 12.6%, respectively. A higher prevalence of overweight and obesity was identified among men (41.2% and 14.0%, respectively) than among women (19.2% and 10.8%, respectively). The majority of participants had a tertiary education, had a middle income, and never smoke. Participants with obesity were more likely to reported more often low levels of physical activity than those without obesity (with obesity: 20.7%; with overweight: 14.2%; with normal weight: 10.9%). Lower score categories of the AHEI were identified among individuals with overweight or obesity than among individuals with normal weight. Mean BMI by subgroups are displayed in Table S2. The overall mean BMI was 25.0 kg/m^2. A higher mean BMI was identified among men than among women (25.9 versus 24.0 kg/m^2).

Multinomial logistic regression

Multinomial logistic regression models revealed that poorer SRH, lower levels of physical activity, lower energy intake, and lower score of AHEI were significantly associated with increased odds of overweight, obesity, and excess weight in men and women compared with normal weight (Table 2). Except for language region and income, most sociodemographic variables included in the regression analysis had statistically significant ORs. Couples with children (OR = 2.33 [95% CI = 1.84−2.95]) or without children (OR = 1.92 [1.56-2.37]) versus adults living alone were associated with higher overweight risk in men, whereas this effect was not identified in women. The lower the education the higher the odds for overweight, obesity. and excess weight in women. Conversely, primary versus tertiary education was inversely associated with overweight, obesity, and excess weight in men. Only Italian language region versus German language region was positively associated with higher obesity and excess weight risk in men (OR = 1.17 [1.14−1.20], OR = 1.05 [1.004−1.09], respectively) and lower obesity risk in women (OR = 0.51 [0.44−0.58]). Per year of increase in age we identified an OR between 1.02 and 1.05 for overweight, obesity, or excess weight in men and women. Sex differences regarding educational level, income, household status, smoking, and their association with overweight, obesity, or excess weight were found (for exact results, see Table 2). The probability of having obesity (Fig. 1) increased with increasing age. However, this probability was associated with lower AHEI score but inversely (men) or not at all (women) associated with energy intake.

Cluster analysis

Four sociodemographic and lifestyle clusters were identified among participants with excess weight (*n* = 891, 100%) (Fig. S3). The characteristics of the patterns are presented in Figure 2. The "young living with parents" cluster (14.6%) was mainly characterized by young age, living with parents, and unhealthy diet. In the cluster "men with high educational level" (41.5%), individuals with male sex, high educational level, high energy intake, and individuals living as couple were overrepresented. The "women living alone" cluster (34.9%) was mainly characterized by female sex, living alone, medium educational level, and low energy intake. Low educational level, Italian language region, bad or medium health, and low income characterized the "low educational level and Italian language region" cluster (9.0%). The clusters "women living

alone" and "low educational level and Italian-speaking region" had a slightly higher proportion of people with obesity than the average (v test = 3.1 and 2.6, respectively).

Dietary variables had relatively low associations with the previously defined clusters (Fig. 3). For the "young living with parents" cluster, we identified a tendency toward high intake of sodium, sugar-sweetened beverages and fruit juice, alcohol, and red/processed meat and low intake of fruit and whole grain. The "men with high educational level" cluster had a tendency toward high consumption of red/processed meat and whole grain and low intake of alcohol and PUFA. In contrast, the "women living alone" and the "low educational level and Italian language region" clusters were characterized by low intake of sodium, sugar-sweetened beverages and fruit juice, and red/processed meat. In addition, the "women living alone" cluster had a tendency toward high intake of fruit and PUFA. Population characteristics (BMI ≥ 25 kg/m^2) stratified by cluster are shown in Table S3.

Discussion

Higher age, poor SRH, lower energy intake, and lower AHEI score were the strongest determinants of excess weight in a population representative sample of Switzerland. Furthermore we found four distinct patterns among the participants with excess weight: "young living with parents," "men with high educational level," "women living alone," and "low educational level and Italian language region."

Prevalence of overweight and obesity

The prevalence of overweight and obesity in our study (30.7 % and 12.6%, respectively) is consistent with previous studies in Switzerland (SHS 2012: 30.8% and 10.3%, respectively; Swiss Survey on Salt [SSS]: 32.2% and 14.2%, respectively) [1,2] and low compared with other high-income countries [13] and most OECD (Organisation for Economic Co-operation and Development) countries [23]. The comparisons of our study with the SHS and the SSS should be interpreted with caution because they rely on self-reported anthropometrics, and the population size and the participation rates varied between the studies (participation rate in SHS 54−71% [9,24] and in SSS 10% [25]).

Diet

Participants with excess weight reported lower energy intake compared with people with normal weight. This might be due to several factors. As supposed by other studies [26−31], people with excess weight—in particular, women—tend to underreport their dietary intake. Second, the proportion of participants on a weight-loss diet was higher among people with overweight or obesity (normal weight: 3.8%; overweight: 7.2%; obesity: 14.1%). This reverse causation was mainly driven by women because 14.6% of all women with overweight and 18.8% with obesity reported being on a weight-loss diet, whereas the percentages for men with overweight and obesity were only 4.0% and 10.6%, respectively. Finally, individuals with excess weight might participate (or refuse to participate) in a nutrition survey for other reasons than those with normal weight, and the applied sample weights do not adjust for this participation bias.

Nevertheless, participants with excess weight scored lower on the AHEI, indicating a diet of poorer quality. It is therefore likely that only quantitative and no qualitative underreporting occurred.

Table 1
Sociodemographic and lifestyle characteristics of the study population, Switzerland 2014 to 2015

Variables (and subgroups)	Overall	Underweight (BMI < 18.5 kg/m²)	Normal weight (18.5 ≤ BMI < 25.0 kg/m²)	Overweight (25.0 ≤ BMI < 30.0 kg/m²)	Obesity (BMI ≥ 30.0 kg/m²)	Missing*
Unweighted sample of participants included (*n*)	2057	50	1096	621	256	34
Weighted sample of participants included (*n*)	462 7878.0	109 687.7	2 474 419.2	1 397 486.4	573 125.1	73 159.5
Sex (%)						
Men	49.8	18.8	40.3	68.0	56.3	19.0
Women	50.2	81.2	59.7	32.0	43.7	81.0
Age in years (%)						
18−29	18.8	33.8	25.1	11.9	5.6	15.9
30−44	29.9	36.7	31.3	25.4	28.1	68.9
45−59	29.8	14.9	27.4	35.0	34.1	3.9
60−75	21.6	14.6	16.2	27.8	32.2	11.3
Language region (%)						
German	69.2	73.1	68.9	69.9	68.6	65.8
French	25.2	21.9	25.8	24.6	24.5	27.8
Italian	5.6	5.0	5.3	5.5	6.9	6.5
Nationality (%)						
Switzerland and Lichtenstein	61.4	56.0	59.0	64.2	66.5	61.5
Switzerland and Lichtenstein binationals	13.8	16.6	15.2	12.3	10.8	10.7
Europe	21.5	23.4	22.5	20.8	18.5	24.0
Others	3.1	4.1	3.3	2.2	4.2	3.7
Missing	0.1	0.0	0.0	0.5	0.0	0.0
Education (%)						
Primary	4.7	0.0	4.9	4.2	6.2	2.7
Secondary	42.6	29.0	39.7	43.9	53.7	46.5
Tertiary	52.6	71.0	55.4	51.5	40.1	50.8
Missing	0.1	0.0	0.0	0.5	0.0	0.0
Marital status (%)						
Single	31.1	59.3	38.3	22.0	18.2	21.8
Married	52.2	31.3	47.2	60.0	57.6	66.0
Divorced	12.1	6.3	11.2	12.1	17.4	9.4
Other	4.4	3.1	3.4	5.4	6.8	2.7
Missing	0.1	0.0	0.0	0.5	0.0	0.0
Household income in CHF (%)						
<6000	17.7	35.0	16.5	16.0	23.3	20.3
6000−13 000	39.8	19.7	39.7	42.9	36.0	45.6
>13 000	14.9	4.7	15.9	14.9	11.0	24.3
Missing	27.6	40.6	27.9	26.1	29.7	9.8
Household status (%)						
Living alone	18.1	43.9	18.0	13.2	26.0	15.0
Couple without children	31.7	24.3	29.9	37.2	29.1	17.0
Couple with children	32.8	20.4	31.3	35.1	31.5	67.9
One-parent family with children	4.4	3.4	5.4	3.2	4.0	0.0
Adult living with parents	7.1	8.0	8.0	6.6	5.2	0.0
Others	5.7	0.0	7.4	4.2	4.2	0.0
Missing	0.1	0.0	0.0	0.5	0.0	0.0
Occupation (%)						
No current	25.9	32.1	22.9	27.5	33.3	28.1
Apprentice	1.4	0.0	2.0	0.4	1.3	0.0
Employee-worker	39.4	47.3	43.2	35.1	32.2	39.5
Lower-middle manager	21.2	14.8	20.9	22.0	21.9	16.4
Director−chief officer	9.8	4.4	8.6	12.5	8.8	11.9
Working without specification	2.2	1.4	2.2	2.0	2.6	4.1
Missing	0.2	0.0	0.1	0.5	0.0	0.0
Health status (%)						
Very good	32.3	45.5	38.9	26.5	15.3	34.3
Good	54.8	39.0	52.2	60.7	55.4	46.8
Average	11.4	10.5	8.1	11.0	25.9	19.0
Poor and very poor	1.3	5.0	0.6	1.3	3.4	0.0
Missing	0.2	0.0	0.1	0.5	0.0	0.0
Smoking (%)						
Never	42.9	45.2	44.4	42.5	36.3	46.0
Former	33.6	30.1	31.8	35.1	37.3	44.8
Current	23.3	24.7	23.6	21.9	26.5	9.3
Missing	0.2	0.0	0.1	0.5	0.0	0.0
Physical activity (%)						
Low	12.9	1.9	10.9	14.2	20.7	11.3
Moderate	22.7	27.0	22.7	23.3	16.7	50.6
High	40.3	32.4	43.4	39.7	32.6	17.0
Missing	24.2	38.7	23.1	22.8	29.9	21.1

(*continued*)

Table 1 (Continued)

Variables (and subgroups)	Overall	Underweight (BMI < 18.5 kg/m^2)	Normal weight (18.5 ≤ BMI < 25.0 kg/m^2)	Overweight (25.0 ≤ BMI < 30.0 kg/m^2)	Obesity (BMI ≥ 30.0 kg/m^2)	Missing[*]
Energy intake (kcal) (%)						
Energy < 1670	23.4	24.0	21.9	25.3	25.4	21.2
1670 ≤ Energy < 2090	24.0	19.3	25.5	22.5	23.3	14.2
2090 ≤ Energy < 2550	25.2	29.8	25.3	25.1	22.8	41.2
Energy ≥ 2550	27.4	26.9	27.4	27.1	28.5	23.4
AHEI (%)						
AHEI < 36	27.4	21.6	24.8	28.6	36.4	30.7
36 ≤ AHEI < 44	23.5	22.4	22.5	26.4	21.5	13.6
44 ≤ AHEI < 53	24.7	24.0	24.8	25.7	21.3	30.8
AHEI ≥ 53	24.5	31.9	27.9	19.3	20.8	24.8

24HDR, 24-h dietary recall; AHEI, Alternate Healthy Eating Index; BMI, body mass index; CHF, Swiss franc.

All results of the descriptive analyses are weighted for age group, sex, marital status, major region, nationality, and household status. Variables derived from the 24HDR (energy intake and AHEI) were additionally adjusted for season and weekday. The higher the AHEI score the healthier the diet.

No information on missing data means 0% missing.

[*]This column includes participants without measured body mass index (27 women were pregnant or lactating and 7 participants were handicapped or refused to be measured).

Table 2

Results of the sex-stratified multinomial logistic regression analyses, Switzerland 2014 to 2015 (*n* = 2057)

	Men			Women		
	Overweight	Obesity	Excess weight	Overweight	Obesity	Excess weight
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (y)	**1.03 (1.02–1.04)**	**1.05 (1.04–1.06)**	**1.04 (1.03–1.05)**	**1.02 (1.01–1.03)**	**1.04 (1.02–1.05)**	**1.03 (1.02–1.04)**
Language region						
German	1.00	1.00	1.00	1.00	1.00	1.00
French	0.92 (0.71–1.21)	1.02 (0.90–1.16)	0.94 (0.69–1.29)	1.32 (0.93–1.88)	1.21 (0.75–1.94)	1.27 (0.93–1.74)
Italian	1.00 (0.97–1.04)	**1.17 (1.14–1.20)**	**1.05 (1.00–1.09)**	0.95 (0.60–1.49)	**0.51 (0.44–0.58)**	0.77 (0.53–1.13)
Education						
Tertiary	1.00	1.00	1.00	1.00	1.00	1.00
Secondary	1.14 (0.92–1.41)	**1.73 (1.48–2.03)**	1.25 (0.96–1.62)	**1.48 (1.09–2.02)**	**1.77 (1.18–2.67)**	**1.58 (1.20–2.08)**
Primary	**0.53 (0.51–0.55)**	**0.76 (0.73–0.79)**	**0.58 (0.55–0.62)**	**1.65 (1.27–2.14)**	**1.91 (1.65–2.20)**	**1.71 (1.34–2.20)**
Household income (CHF)						
>13 000	1.00	1.00	1.00	1.00	1.00	1.00
6000–13–000	1.10 (0.89–1.37)	**0.76 (0.61–0.96)**	1.02 (0.82–1.26)	1.08 (0.75–1.55)	**1.68 (1.26–2.26)**	1.22 (0.88–1.68)
<6000	1.11 (0.96–1.27)	1.18 (0.95–1.46)	**1.16 (1.01–1.34)**	1.33 (0.93–1.92)	**2.20 (1.72–2.80)**	**1.52 (1.09–2.10)**
Household status						
Living alone	1.00	1.00	1.00	1.00	1.00	1.00
Couple without children	**1.92 (1.56–2.37)**	**0.73 (0.57–0.94)**	**1.44 (1.09–1.90)**	1.15 (0.81–1.65)	0.65 (0.40–1.05)	0.96 (0.69–1.32)
Couple with children	**2.33 (1.84–2.95)**	**1.31 (1.04–1.65)**	**1.89 (1.47–2.44)**	1.18 (0.84–1.65)	1.02 (0.65–1.60)	1.09 (0.81–1.48)
One-parent family with children	**1.47 (1.44–1.51)**	**0.64 (0.64–0.65)**	**1.11 (1.08–1.15)**	**0.67 (0.51–0.87)**	**0.60 (0.51–0.70)**	**0.64 (0.48–0.84)**
Adult living with parents	**2.49 (2.22–2.81)**	**1.29 (1.26–1.33)**	**2.01 (1.72–2.36)**	1.18 (0.75–1.87)	1.07 (0.91–1.24)	1.13 (0.73–1.74)
Others	**1.16 (1.08–1.24)**	**0.12 (0.12–0.12)**	**0.75 (0.69–0.82)**	0.99 (0.86–1.14)	**1.62 (1.35–1.95)**	1.22 (1.00–1.48)
Smoking						
Current	1.00	1.00	1.00	1.00	1.00	1.00
Former	**1.30 (1.12–1.52)**	1.18 (0.91–1.52)	**1.28 (1.04–1.57)**	1.11 (0.73–1.69)	0.81 (0.61–1.09)	1.01 (0.67–1.50)
Never	**1.38 (1.12–1.70)**	1.14 (0.91–1.41)	**1.32 (1.07–1.63)**	1.24 (0.83–1.83)	0.81 (0.60–1.10)	1.06 (0.73–1.55)
Health status						
Very good	1.00	1.00	1.00	1.00	1.00	1.00
Good	**1.69 (1.31–2.19)**	**1.73 (1.46–2.05)**	**1.70 (1.32–2.18)**	**1.47 (1.05–2.06)**	**3.01 (2.11–4.28)**	**1.74 (1.27–2.38)**
Average	**1.71 (1.49–1.96)**	**3.51 (2.98–4.13)**	**2.15 (1.77–2.61)**	1.39 (0.83–2.31)	**8.88 (6.74–11.68)**	**2.79 (1.72–4.51)**
Poor and very poor	**3.77 (3.70–3.83)**	**5.39 (5.30–5.48)**	**4.40 (4.36–4.44)**	**0.53 (0.51–0.55)**	**12.40 (11.59–13.26)**	**2.24 (2.11–2.38)**
Physical activity						
High	1.00	1.00	1.00	1.00	1.00	1.00
Moderate	1.09 (0.84–1.40)	**1.30 (1.17–1.44)**	1.13 (0.85–1.52)	**1.49 (1.06–2.09)**	1.34 (0.86–2.09)	**1.45 (1.06–1.98)**
Low	1.20 (0.96–1.50)	**2.51 (2.14–2.95)**	**1.47 (1.09–2.00)**	1.46 (0.89–2.38)	**4.83 (3.04–7.67)**	**2.41 (1.58–3.68)**
Energy intake (kcal)[*]	1.00 (1.00–1.00)	1.00 (1.00–1.00)	1.00 (1.00–1.00)	1.00 (1.00–1.00)	1.00 (1.00–1.00)	1.00 (1.00–1.00)
AHEI	**0.99 (0.98–1.00)**	**0.98 (0.96–0.99)**	**0.98 (0.97–0.99)**	**0.98 (0.97–0.99)**	**0.96 (0.94–0.98)**	**0.97 (0.96–0.98)**

AHEI, Alternate Healthy Eating Index; BMI, body mass index; CHF, Swiss franc; CI, confidence interval; OR, odds ratio.

Men: overweight: OR = 0.9997 (95% CI = 0.9996–0.9999); obesity: OR = 0.9996 (0.9994–0.9998); excess weight: OR = 0.9997 (0.9996–0.9998).

Women: overweight: OR = 0.9993 (0.9990–0.9996); obesity: OR = 0.9998 (0.9994–1.0001); excess weight: OR = 0.9995 (0.9992–0.9997).

Definition of BMI groups: overweight: 25.0 ≤ BMI <30.0 kg/m^2; obesity: BMI ≥ 30.0 kg/m^2; excess weight: BMI ≥ 25.0 kg/m^2.

Results from two mutually adjusted models are shown: one differentiating between overweight and obesity and one combining overweight and obesity (BMI ≥ 25.0 kg/m^2).

In all regression models, normal weight (18.5 ≤ BMI <25.0 kg/m^2) was the reference group.

For the participants with no measured BMI, a composite BMI (self-reported weight before pregnancy and measured height) or self-reported BMI was considered.

All results are weighted for age group, sex, marital status, major region, nationality, and household status.

Statistically significant results are shown in bold. (95% CI does not include 1.00)

We imputed the most common value for all variables introduced in the regression analyses based on multivariate imputation by chained equations.

The higher the AHEI score, the healthier the diet; maximum score = 110.
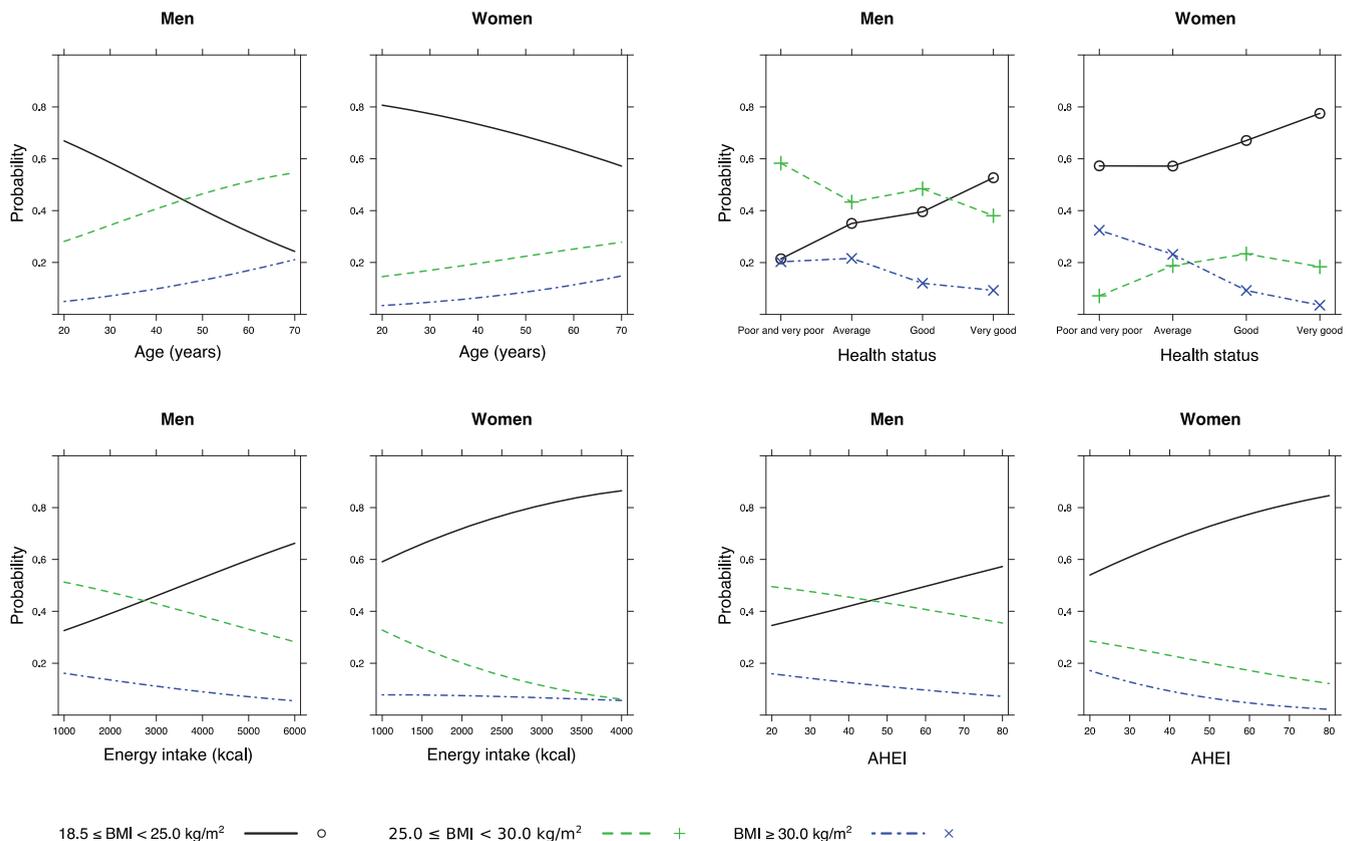
[*]Four decimal places for total energy intake.

Fig. 1. Effect plots of age, self-rated health status, energy consumption, and AHEI stratified for sex, Switzerland 2014 to 2015 (*n* = 2057). The effect plots show the probability for being in one of the defined BMI groups as predicted by the mutually adjusted multinomial regression models that were weighted for age group, sex, marital status, major region, nationality, and household status (all results are shown in Table 2). Example: The probability of having obesity (BMI ≥ 30.0 kg/m²) decreased with higher AHEI score in men and women. The results of people with underweight (BMI <18.5 kg/m²) are not reported because of the small sample size. The higher the AHEI score, the healthier the diet; maximum score = 110. AHEI, Alternate Healthy Eating Index; BMI, body mass index.

Socioeconomic inequalities

Similar sociodemographic and lifestyle factors as analyzed in the present study have been found to be associated with weight gain over the course of life [32], indicating the importance of such factors. In developed countries, low socioeconomic status (SES) was associated with increased risk for excess weight compared with high SES [24]. This pattern has also been reported in studies on the Swiss population [24,25]. The present study, however, confirmed these findings for women but not for men. The same pattern was found in a systematic review by Newton et al. [33], which suggested that among men with low SES, physically demanding (manual) jobs might partially explain this pattern. Furthermore, they suggested that men do not have the same ideals regarding weight as women and that women with high income can more easily sustain these ideals compared with women with low income [33]. In our study, 35% of all men with primary education are in the youngest age group (18−29 y). Therefore they might not have completed their education yet. However, our findings regarding education should be interpreted with caution because only a small sample of the study population reported primary education (4.7%). This percentage is lower than in the general population (12% in 2014) [34] of Switzerland, suggesting a particularly low participation rate among people with primary education.

Language region

Even though Chatelan et al. [12] and other studies [6,35−37] found large differences in dietary intake between the three language regions,

we observed only significant associations between participants with excess weight and participants with normal weight in the Italian language region versus the German language region. However, with approximately 2000 participants, the power provided by the menuCH study is limited, particularly when the population and clustered behaviors are stratified by language region. In contrast to our study, the much larger SHS 2012 found no association between participants with excess weight and participants with normal weight for the Italian language region versus German language region but did find an association for the French language region versus German language region [9]. It is unclear if a sex-stratified analysis in the SHS would have produced different results. Data from vital statistics (death registry) clearly indicate different causes-of-death patterns in the Latin and the German parts of Switzerland with, for example, higher rates of cardiovascular disease in German Switzerland, a higher mortality as a result of liver cancer and cirrhosis in the French part, and a lower mortality from prostate cancer in the Italian part [7,37]. This corroborates the assumption that the postulated cultural differences in diet and lifestyle are real.

Other lifestyle factors

No difference between BMI groups was identified concerning smoking; only a positive association of never smoking and former smoking versus current smoking was found for overweight and excess weight in men. These findings are at odds with the SHS [38] and the SSS [25]. However, discrepancies about the association of smoking and obesity exist in literature [28].
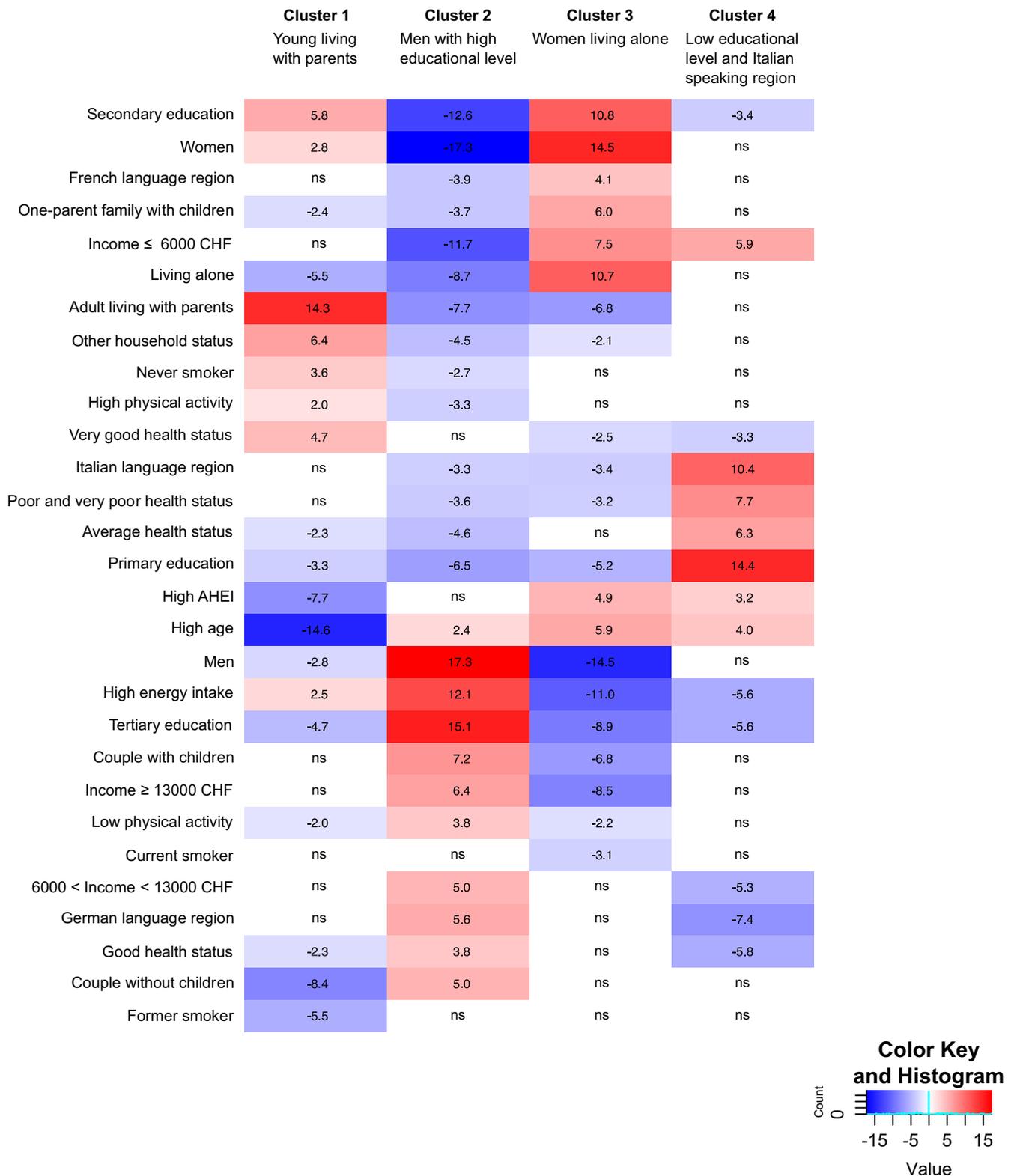
Fig. 2. Sociodemographic and lifestyle patterns among excess weight clusters, Switzerland 2014 to 2015 (*n* = 891). The present heatmap was derived from factor analysis of mixed data and hierarchical clustering among participants with excess weight (BMI ≥ 25.0 kg/m²). Moderate physical activity was not significant and therefore not reported in this figure. Colors indicate overrepresentation (red) or underrepresentation (blue) of the given variable for a specific cluster. For example, in cluster 1, individuals with higher age are underrepresented. In cluster 2, individuals with tertiary education are overrepresented. The higher the AHEI score, the healthier the diet; maximum score = 110. AHEI, Alternate Healthy Eating Index; BMI, body mass index; CHF, Swiss franc; ns, not significant.

Highest AHEI component tertile	Cluster 1 Young living with parents	Cluster 2 Men with high educational level	Cluster 3 Women living alone	Cluster 4 Low educational level and Italian speaking region
* Sodium	-4.0	ns	2.7	3.2
* Sugar-sweetened bev.	-4.0	ns	2.4	3.2
Fruit	-4.0	ns	2.9	ns
* Alcohol	-2.3	2.4	ns	ns
Whole grains	-3.6	3.0	ns	ns
PUFA	ns	-2.1	3.3	ns
* Red/processed meat	-3.6	-4.1	5.1	2.7

Color Key and Histogram

Fig. 3. Dietary components of AHEI among excess weight clusters, Switzerland 2014 to 2015 (*n* = 891). The present heatmap was derived from factor analysis of mixed data and hierarchical clustering among participants with excess weight (BMI ≥ 25.0 kg/m^2). The higher the AHEI score, the healthier the diet; maximum score = 110. The score of each AHEI component could range from 0 to 10. Only the highest tertiles of each AHEI component are reported if significant. Colors indicate overrepresentation (green) or underrepresentation (red) of the given AHEI component tertile for a specific cluster. For example, in cluster 1, individuals with high AHEI score concerning sodium are under-reported. In cluster 3, individuals with high AHEI score regarding red/processed meat are overrepresented. *High score = low consumption. AHEI, Alternate Healthy Eating Index; BMI, body mass index; ns, not significant; PUFA, polyunsaturated fatty acids.

Our findings are in line with previous studies suggesting higher risk of obesity for low physical activity compared with high physical activity [25,28]. In our study a stronger association was found in women than men. This also was identified among others in a population-based study conducted in Sweden [28].

Of all factors, SRH was the one with the strongest association with overweight, obesity, and excess weight in both sexes with much higher odds in people reporting poor or very poor SRH. This finding is in agreement with other studies [39,40]. In studies from Switzerland with mortality follow-up, SRH was a strong, dose-dependent predictor of survival, independently of other self-reported and clinical risk factors and of preexisting diseases [41].

Clustering

To our knowledge, this is the first study examining sociodemographic and lifestyle clusters among people with excess weight. Few studies are available examining clusters among people with obesity [42]. Like other studies [43,44], we used a two-step strategy for the identification of sociodemographic and lifestyle patterns, following up FAMD with hierarchical clustering. This strategy allows for removal of the non-interpretable variation ("noise") in sociodemographic and lifestyle factors before the identification of discrete patterns on the remaining interpretable variation. Clustering without FAMD resulted in seven clusters (data not shown), which, given the small sample size, would have reduced the interpretability of the partition. We acknowledge that both principal component and clustering methods are partially based on arbitrary analytic decisions (e.g., number of dimensions or clusters to retain) [45] and may have limited stability [46,47] or reproducibility [48,49], as reported for dietary patterns.

Limitations

The present study had several limitations: First, menuCH was a cross-sectional study and therefore causality could not be assessed.

Second, compared with the SHS 2012 the proportion of participants with high educational level was greater in the menuCH study population. The number of adults considering their health status as good or very good and the proportion of adults fulfilling the physical activity recommendation were also higher and the prevalence of smokers was lower in the menuCH study population compared with the SHS [11]. This indicates that the menuCH study participants were more health conscious than the general Swiss population, leading to potential healthy participant bias. Given that and the low participation rate (38%), generalizability of the results should be conducted with caution even though we applied sampling weights. Third, most considered factors were self-reported and diet was assessed on 2 d; thus validity and reliability are limited. Fourth, we acknowledge that BMI does not take body composition into account and participants with a relatively high muscle mass may be misclassified as overweight or obese [50]. Nevertheless in the general population the correlation between total body fat and BMI is high [51].

Conclusions

Our findings emphasize the importance of considering people with excess weight as a heterogeneous group because it is already known from metabolic studies [52]. Further studies should analyze similar population-based samples in other countries to confirm this finding. Based on this probably novel approach of identifying subgroups among people with excess weight, population-specific and tailored public health interventions could be planned and implemented. For instance, because there is evidence that health status is an indicator for morbidity and mortality [40,41] and health status was strongly associated with overweight and obesity in our analysis, preventive interventions (including therapeutic approaches) should specifically focus on these subgroups defining themselves as unhealthy. Instead of uniformly advising standard energy-restricted or low-carbohydrate diets to all

obese individuals, an individualized approach with tailored dietary measures may be more promising.

Acknowledgments

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2019.01.001.

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